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CONTENTS

The Progress of Forest Research in India, 1931-32.

CHAPTER I.

THE FOREST RESEARCH INSTITUTE.

GENERAL.

The economic disaster that has overtaken the world should be an incentive to forest research rather than occasion for its curtailment; it is unlikely that for some years to come it will pay to work the more inaccessible forests, or to market the less useful produce, but research can extend the limits in both cases with advantage to the producers and to the consumers. In the past new or extended uses for timber are denoted by ever-increasing demand, and there is no reason to suppose that the limit has now been reached. In India few timbers and some minor forest products are well known, and organised research only can investigate and draw attention to the properties of others, or discover better means of growing or using those already known. The area of forest in India is vast and the scope for development immense.

In the circumstances it is a tragedy that so soon after the opening of the Forest Research Institute drastic retrenchment of expenditure became necessary. Almost throughout the year the activities of each branch and section have been subject to the closest critical examination; reduction of expenditure by 50 per cent and more, and even complete closure of the Institute have been suggested. A 33 per cent reduction has now been decided upon, and it is hoped that it will be possible to maintain all branches of research work though some will be on a very reduced scale. The number of experienced forest officers remaining on the staff will be perilously near the minimum necessary to ensure adequate attention to the practical side of some investigations and to the application of the results.

The constitution and functions of an Advisory Board for the Institute have been considered, but owing to the expense involved its creation has been deferred. Owing to reduction of staff throughout the Forest Department, the I. F. S. College is shortly to be closed and a two years course for Forest Rangers has been postponed. It is to be hoped that at some future date training as well as the research activities will be centralised on the Forest Research Institute estate.

NOTE.—This Report is printed on paper made in the Paper Pulp Section of the Forest Research Institute, Dehra Dun, from the bamboo *Dendrocalamus strictus* from Hyderabad the stems of which flowered 3 or 4 years ago.

In the following chapters will be found an account of work done during the year in the five branches of the Forest Research Institute and, in order to avoid the delay which is inevitable if the reports of research in the provinces are incorporated, these will be published separately. A statement of publications issued during the year is given, and appendices show the names of officers in charge of branches and sections, the expenditure incurred, and a full list of publications to date.

In the Silviculture Branch considerable progress was made with experimental work. The demonstration area which covers about 200 acres is now almost completely stocked; the death of *Gmelina* still continues and the cause has not yet been determined. The new Statistical Code was issued early in the year and will greatly assist the standardisation of the statistical basis of working plans; revision of the Deodar Yield Tables was taken in hand. Some field work was done in the Punjab and Central Provinces, and computations were made for the records of 444 sample plots and a total of 1,327 permanent sample plots were under observation. Progress was made with the preparation of Volume Tables and a variety of statistical work was carried out for the provinces; additions were made to the photographic collection, and prints and lantern slides were sent to the provinces and abroad. The referencing of silvicultural literature and the preparation and revision of ledger files suffered greatly from the lack of staff; it is much to be regretted that the importance of records in this branch was not recognised by the retrenching authorities. Every effort is being made to provide for tours by the staff as it is only by touring that satisfactory co-operation with the provinces can be ensured, and without it much of the fundamental research loses value. Mr. Champion visited the research centres of Central Europe and experimental areas in the United Kingdom, his interesting report will be of great use to the Forest Research Institute and to the provinces.

Over five hundred specimens were identified by the Forest Botanist during the year and progress was made with the identification and description of grasses to complete Duthie's Flora of the Upper Gangetic Plain. 2,719 sheets were added to the herbarium and a short account of the collection was published. Considerable additions were made to the arboretum and valuable information obtained regarding the development of several species; large quantities of seed were supplied to a number of countries with a guarantee of identity and soundness. In the mycological section trees inoculated with *Fusarium* and *Peridermium* were under observation, and it is proposed to make a further study of the alternate hosts of the latter. The 'damping' off of seedlings in nurseries was under investigation and cultures of wood rotting fungi were prepared.

Work in the Economic Branch has been in process of curtailment almost throughout the year, but it is hoped that with about half the funds previously provided and a considerable reduction of staff it will still be possible to make good use of the excellent equipment that is available. All sections of the branch are to be maintained, but with an assistant only in charge of Minor Forest Products.

Over five hundred identifications were carried out in the Wood Technology Section, and a key to the important Indian railway sleeper woods was prepared. Anatomical studies of a number of woods were made and photomicrographs were prepared for special purposes and to add to the reference collection; additions were made to the authentic collection of wood specimens.

In the Timber Testing Section over 21,000 observations were recorded during the year, and the computation of results was brought up to date; the interchange of laboratory and computing staff was continued with a view to raising the general standard of qualifications. Apart from investigations in accordance with approved projects, a number of special tests were made and a large variety of enquiries answered. Mr. Seaman, the Officer-in-Charge of the Section, undertook additional duties as Assistant Forest Economist throughout the year.

In the Seasoning Section owing to re-construction of the kiln only 35 charges of timber were put through: assistance was given to the East Indian Railway with their kilns at Lalloogh. Air seasoning experiments confirmed that 2 or 3 months suffice for one inch planks of most species. The surface treatment of railway sleepers of *Terminalia tomentosa* indicates possibilities of reducing the tendency to crack and split, and a series of experiments in Punjab timber depots denoted the effect of different methods of stacking sleepers; the water seasoning of *Pinus jacquemontiana* proved unsatisfactory. Rates of drying, shrinkage, collapse and specific gravity were subjects of laboratory tests.

Preservative treatment of most of the timbers likely to be suitable for railway sleepers has now been tried, but some addition was made to the sleepers already laid in the lines for practical tests. The Powell process of treatment was subjected to special study in the Wood Preservation Section, and also a new method of fixing arsenic which it is hoped will prove a success.

Apart from supplying samples of timber for display or investigation throughout the Institute, reports were made on the working qualities of a number of timbers, and trade enquiries were answered by the Wood Workshop Section. Veneers and plywoods were made from a variety of timbers and in some cases tested as tea boxes; glue tests are an important part of these experiments.

In the Minor Forest Products Section a portable charcoal kiln was designed to suit Indian conditions; a practical test gave promising results. A hydraulic briquetting press was installed and it is hoped to produce a satisfactory charcoal briquette; match veneering and splint chopping machines were installed too late for tests of woods to be made. Other subjects such as the borer attack on bamboos, the calorific values of woods, uses for third quality turpentine and the study of crude drugs were largely dealt with by the branches more intimately concerned. The Minor Forest Products museum was greatly improved and some progress was made with the experimental garden.

In the Paper Pulp Section the mechanical treatment of bamboos, the preparation of pulp suitable for the artificial silk industry and the preparation of kraft and wrapping papers received special attention. Experiments were made with a number of grasses and some other raw materials; the Tariff Board have recommended that the section should become a clearing house for research work on indigenous pulp materials.

The Entomological Branch records an interesting account of control measures against the *sal* borer in the Central Provinces; these measures have been most effective and have saved a vast quantity of timber from destruction. Insects attacking the teak and a number of other trees or timbers were studied, and the entomological investigation of the spike disease of sandal trees was continued. 176 consignments of attacked material and insect specimens were received for breeding, identification or report, and over 25,000 insects bred were set. About 500 species were added to the identified insect collection, and a few papers dealing with new species have already been published. The Systematic Entomologist continued the study of coleopterous larvae and of cerambycidae.

The Bio-Chemist records the results of his study of several drugs, oils, fats, essential oils, and a colouring matter. Apart from these investigations he has carried out soil analyses and a determination of the calorific value of a number of woods. The composition "Fridera" for re-conditioning the spike holes of railway sleepers has now been patented; it is under test in several lines, and results to date are promising.

Mr. A. D. Blascheck held the post of Inspector General of Forests and President, Forest Research Institute and College, throughout the year, and he wishes to record his appreciation of the work done by his staff in spite of the uncertainty of their own future as well as that of the Forest Research Institute, and in spite of repeated suggestions to curtail or abandon the work they were doing. As Personal Assistant, Mr. H. S. Deans, Deputy Conservator of Forests, ably relieved the President of much routine; some relief from office work has been afforded in four of the branches by the creation of a central office.

CHAPTER II.

SILVICULTURE BRANCH.

1.—Experimental Silviculture.

(i) *General.*

Three parts of the Indian Forest Records were published during the year:—

Vol. XVI, Pt. V .	. Investigation on the seed and seedlings of *Shorea robusta.*
Vol. XVI, Pt. VI .	. Use of stumps (root and shoot cuttings) in artificial regeneration.
Vol. XVI, Pt. VII.	. Notes on *Pinus longifolia.* The plantations in Dehra Dun and the Central Provinces and miscellaneous seed studies.

A feature of the year has been the progress made in the experimental section of the branch. The records of all the current investigations have been scrutinised and the projects revised in the light of experience, with improvement in the technique where possible. The publications just mentioned are the results of the compilation of the results obtained from selected sets of experiments, and there are a good many more awaiting similar attention. This work has only been possible by the assiduity of the Experimental Assistant and the Ranger.

Experimental plot files received from the provinces have been scrutinised and when occasion arose suggestions have been made concerning the course of the experiment or the maintenance of the actual records. A good many experimental plots in North Bengal were visited with the Conservator and Bengal Silviculturist in January 1932, and their problems discussed on the spot.

The Kaunli experimental garden has again been taken over from the Saharanpur Division which no longer required it. The extra area will be useful for long term crop investigations such as comparison of racial forms, etc.

(ii) *Natural regeneration.*

The study of annual seed production and fertility of individual trees of *Anogeissus latifolia* was continued for the fourth year (Expt. 44).

The figures have fluctuated a good deal as shewn in the following statement and will be studied when more data have been accumulated :—

Year.	Average seed crop per tree in lbs.	Average germinative capacity per 10,000 seeds.
1928	5·4	10 1
1929	21·3	12·3
1930	22·5	43·0
1931	4·4	23·7

Seed crops (Expt. 10) from individual trees of *Shorea robusta*, *Pinus longifolia* and *Terminalia tomentosa* were again recorded. 1931 was a good seed year for all these species. The records must be continued several more years before analysis can be profitable.

Causes of dying back (Expt. 43). An investigation on *Bombax malabaricum* is in progress but no definite results have been obtained so far.

(iii) *Investigations on seeds.*

(*a*) *Routine seed weighments and germination tests* have been continued. During the year 122 weighments were made including eleven species for which no previous records were available. Reprinting of the Forest Bulletin on the subject may be reconsidered in 1932, a good deal of data from various sources having accumulated since 1928.

Effect of size of seed on germination and growth of seedlings was studied in *Terminalia tomentosa*. Germination and plant per cent were found to be best for middle sizes, falling off for the biggest and small seed, and the average height of plants showed the same tendency. Germination was however very poor for unknown reasons, and the experiments will be repeated as these conclusions can only be considered tentative.

(*b*) *Seed storage* (Expt. 12).

The following germination results were obtained for seeds stored in sacks and sealed tins :—

Serial No.	Species.	Year of storage.	Initial germinative capacity per cent.	1930.			1931.		
				No. of years stored.	Germinative capacity per cent.		No. of years stored.	Germinative capacity per cent.	
					In sack.	In sealed tin.		In sack.	In sealed tin.
1	Acacia catechu	1927	*(85·5)	3	..	53	4	..	1
2	Albizzia procera	,,	..	3	..	85·7	4	..	56
3	Albizzia lebbek	,,	(23·5)	3	..	16	4	..	13
4	Bauhinia variegata	,,	(100)	3	..	11·5	4	..	0
5	Dalbergia sissoo	,,	(79)	3	..	67	4	..	43
6	Pongamia glabra	,,	(11)	3	..	1·5	4	..	0
7	Sapium sebiferum	,,	(33)	3	..	2·5	4	..	0
8	Xylia dolabriformis	,,	(38)	3	..	1	4	..	·5
9	Zizyphus jujuba	,,	(85)	3	..	80	4	..	24·5
10	Acacia catechu	1928	(46)	2	3	3·7	3	0	1
11	Albizzia lebbek	,,	32	2	26·5	27	3	26·5	4
12	Albizzia procera	,,	50·5	2	45	33·7	3	10	22
13	Bauhinia variegata	,,	96	2	0	56·5	3	0	0
14	Butea frondosa	,,	83	2	0	0	3	..	0
15	Cassia fistula	,,	19	2	19	28·5	3	26·5	44
16	Dalbergia sissoo	,,	91	2	0	92	3	0	84
17	Holarrhena antidysenterica	,,	83·5	2	4	?	3	0	20
18	Lagerstroemia flos-reginae	,,	28·5	2	0	29·7	3	0	0
19	Pinus longifolia	,,	82	2	71	90	3	6	83
20	Sapium sebiferum	,,	11	2	0	0	3	0	0
21	Terminalia belerica	,,	54	2	0	18·5	3	0	3
22	Terminalia tomentosa	,,	36	2	29	38	3	0	25
23	Zizyphus jujuba	,,	86	2	97	97	3	50	72
24	Dendrocalamus strictus	1930	56·5	0	.	..	1	1	54

* Entries in Col. 4 which are enclosed in brackets refer to germination after one year's storage in sacks

(c) *Aids to germination* (Expt. 13).

An experiment was made with *Terminalia chebula* and gave the following results :—

Treatment.	Germination per cent.	Plant per cent.
Pulp not removed, no treatment . . .	33·2	31·6
Pulp not removed, 15 minutes in boiling water	0	0
Pulp removed, 3 days in cold water . .	26·5	25·3
Pulp removed, 7 days in sun	21·6	21·1

It will be seen that the untreated control gave the best germination and plant per cent which was unexpected. A line sowing with the same lot of seed, unpulped, made at the break of the monsoon gave nearly 100 per cent germination.

With *Acacia arabica* an old experiment was repeated with seed collected off the trees and that collected from goats' droppings. Seeds collected from the trees and soaked gave the best results and the hot water treatment is all that this species needs.

Treatment.	Germination per cent 10 days after sowing.	Germination per cent 8½ months after sowing.
From trees, unsoaked	14·6	40 3
From trees, soaked for 4 hours in water at 103°—105°F.	67·6	81·6
From goat droppings, unsoaked . . .	10·3	31·6
From goat droppings, soaked for 4 hours in water at 103°—105°F.	51·3	62·6

Buxus seed was sown on different media with watering of the seed by percolation. It germinated quite well after having been kept under glass during the winter : this species had proved very difficult in previous attempts to grow it.

(iv) *Investigations on seedlings.*

Seedling studies (Expt. 4) have been continued as before. The following species have been added to the list of those already dealt with :—

Now completed.

(1) *Acacia modesta.*
(2) *Amoora wallichii.*
(3) *Celtis tetranda.*

Partly done.

(1) *Buxus sempervirens.*
(2) *Crataeva religiosa.*
(3) *Diospyros assimilis.*

(4) *Ehretia laevis.* (4) *Nyssa sessiliflora.*

(5) *Hardwickia pinnata.*

(6) *Olea glandulifera.*

(7) *Quercus griffithii.*

(8) *Vitex altissima.*

Cutting back of misshapen plants (Expt. 60).—An experiment with *Eugenia jambolana* was carried out to see if plants rendered bushy by the attacks of a small bud worm (weevil) could be got to grow up. 90 such misshapen plants were selected and divided into 2 comparable lots. One lot was kept as control and the other lot cut back near ground level in the hope that there would be no loss of height at the end of the season and a gain in shape—unfortunately the insect attacked all the buds again and no gain was obtained.

Cutting back of teak saplings after frost (Expt. 55).—100 damaged plants were selected and divided into two comparable lots; one lot of 50 was cut back and the other left to itself. After one year's growth, the uncut lot showed a significantly superior height growth of 16·9″± 3·45 on a height of about 12 ft., but the plants were of course of less satisfactory shape.

Burning back of sal line sowings (Expt. 59) with and without cutting back the shoots before burning was repeated a second year. No significant difference has been found in the height growth of the coppice shoots after two years' repetition of burning, etc. Burning will be continued at least one year more.

This experiment has been replicated in another compartment and again no significant differences found at the end of the season's growth.

(v) *Investigations on trees and crops.*

(*a*) *Seasonal height growth* (Expt. 2).—Measurements were continued on 11 species and 2 more were added during the year.

Seasonal height growth observations were also started on 10 plants of each of the origins of *chir* pine and *Gmelina* to compare their phenology in relation to frost damage and rate of growth.

The data collected are being compared with the Wood Technologist's results on diameter increment.

(*b*) *Phenological data* (Expt. 1).—Observations were continued on eleven species and three more added during the year, *viz.*, *Bombax*, *Adina* and *Eugenia jambolana*.

Adequate data have been accumulated for preliminary compilation which it is hoped to undertake during the year 1932-33.

(*c*) *Inheritance of individual characters* (Expt. 7 and 67).—The *chir* pine plots raised from seed of individual twisted fibre trees have been practically completed.

60 solid bamboo (*Dendrocalamus strictus*) rhizomes from the Central Provinces were put out, but owing to their drying out in transit, only 9 have survived.

Terminalia tomentosa seed from trees of known spiral grain was put out but damped off.

(*d*) *Inheritance of climatic race characters* (Expt. 6(i)).—Preliminary seed-testing work and raising of stock for the co-operative teak seed origin investigation was begun. Relatively poor development was obtained in the nursery beds and heavy casualties were incurred during the winter. It will probably be necessary to wait till 1933 to make plantations. Reports have been received from all participants; although some of the plots have made a good start, rather a lot of them are disappointing, general failure with S. Burma seed being unexpected. Arrangements have been made for replacing failed origins and filling in casualties in the plots well enough stocked to be worth maintaining.

Experiments on *Shorea, Pinus longifolia, Tectona, Gmelina, Terminalia tomentosa, Acacia catechu, Adina, Bombax, Quercus incana, Albizzia procera* and *Butea* are in progress and doing well.

(*e*) *Inheritance of physiological race characters* (Expt. 6(i)).—*Butea* (C. P. lac forms), *Schleichera* (curly and straight leaved lac forms) were put out in small compact plots, but have suffered severely from frost and rats.

(*f*) *Soil and quality class indicators* (Expt. 48).—Studies were continued in the Demonstration Area plantations: five more quadrats were laid out in addition to the five existing ones which were found inadequate. The records have been gone through and the project improved in light of experience to date.

(*g*) *Congestion in bamboo clumps* (Expt. 8).—Seed from an uncongested area was raised and is ready to go out to complete the bamboo plots.

Rats continue to do much damage to the plantations despite efforts to exterminate them and none of the plantations are ready for testing possible methods of inducing congestion.

(*h*) *Effect of autumn irrigation on leaf fall* (Expt. 65).—To test the statement that the end of the season's activity in teak is determined by fall of soil moisture resulting in leaf fall, a set of plants was irrigated at intervals from the end of the monsoon till leaf-fall, a comparable set being kept as control unirrigated. The watering made no difference whatever.

(vi) *Artificial regeneration.*

Weather conditions effecting results were as follows. In 1930 the monsoon ended exceptionally early (August 21st), and December was very frosty. Good winter rain fell in February 1931, followed by fair hot weather showers. The monsoon broke on July 1st and was very feeble but well distributed. The 1931-32 cold weather was completely rainless but frost was slight.

(*a*) *Line sowings* (Expt. 17) were tried with *Pterospermum acerifolium*, *Carallia integerrima*, *Terminalia chebula* and *Celtis tetranda*, and all made a satisfactory start.

The five species sown in 1930, *viz. Boswellia serrata*, *Butea frondosa*, *Cedrela toona*, *Lannea grandis* and *Canarium euphyllum*, had all failed by the end of the next cold weather except for the *Butea* which was later destroyed by rats; this failure must be ascribed to the drought and frost.

(*b*) *Rains entire transplanting in the open* (Expt. 18).—The following species were tried in 1931, the survival percentage at the end of the year being given in brackets:—

Bauhinia retusa (76%), *Celtis tetranda* (44%), *Pinus longifolia* with naked-roots (26%), and *Pterospermum acerifolium* (86%).

No practical conclusions can be drawn till the plants have got over a dry season. Of the species tried in 1930, *Trewia nudiflora* and *Butea frondosa* can be considered to have given satisfactory results. *Lannea grandis*, *Bischofia*, and *Phoebe lanceolata* started fairly well, but the exceptionally unfavourable 1930-31 season proved too much for them, whilst *Santalum album* was actually killed off cent per cent.

(*c*) *Rains entire transplanting in cleared lines* (Expt. 19).—The following species were put out in 1931:—

Pterospermum acerifolium (94%), *Celtis tetranda* (92%), *Schleichera trijuga* (86%), the % figure indicating survival at the end of the year. In 1930 the same species were used, with the exception of *Lannea*, as in the previous experiment. *Bischofia*, *Phoebe* and *Santalum* appear to have been helped to survive by the shade, but *Trewia* lost greatly both in survival and height: even so, only 6% *Phoebe* and 4% *Santalum* survived.

(*d*) *Winter transplanting in the open* (Expt. 20).—In February 1931, four species were put out and the survival in December 1931 was as shewn:—*Dymenodictyon excelsum* (89%), *Broussonetia papyrifera* (80%), *Cedrela toona* (5%) and *Schleichera trijuga* (12%).

(*e*) *Winter stump planting in the open* (Expt. 23).—Only *Erythrina suberosa* was put out in February 1931 and in December 75% were alive; *Butea frondosa* and *Albizzia lebbek* were added in February 1932

(*f*) *Rains stumps planting in the open* (Expt. 21).—The following ten species were put out in July 1931 :—

Adina sessilifolia, Albizzia lebbek, Broussonetia papyrifera, Butea frondosa, Cedrela toona, Lannea grandis, Phoebe lanceolata, Santalum album, Terminalia myriocarpa and *Xylia xylocarpa*. Survivals in December were 90-100% except for *Terminalia myriocarpa* (37%) which is always liable to be attacked by white ants, and *Santalum album* (80%).

Of the species put out in July 1930, the percentages shewn below have survived to the end of the second growing season :—

1930 rains stump planting in the open.

Species.	Planted on.	Survival per cent on 2nd January 1931.	Survival per cent on 4th January 1932.	Remarks.
Swietenia macrophylla. .	7-7-30	18%	0	Died during the first hot weather.
Cinnamomum cecidodaphne .	8-7-30	36%	0	Killed by frost.
Anogeissus latifolia . .	9-7-30	72%	71%	Average height, 23".
Alnus nitida . . .	10-7-30	60%	0	Killed by frost.
Terminalia myriocarpa .	2-8-30	0	0	Died at the end of the rains.

(*g*) *Rains stump planting in cleared lines* (Expt. 22).—Five species were put out in July 1931, *viz.* (1) *Albizzia lebbek*, (2) *Broussonetia papyrifera*, (3) *Butea frondosa*, (4) *Cedrela toona*, and (5) *Xylia xylocarpa*.

All started well except the *Xylia* of which only 44% were alive in December. Of the 1930 trials, *Anogeissus latifolia* has done quite well with 80% survivals at the end of 1931. *Alnus nitida* started well but was entirely lost during the hot weather, as also was the case with *Cinnamomum cecidodaphne*. *Swietenia macrophylla* was a failure from the start.

(*h*) *Effect of injury to stumps* (Expt. 30).—Two forms of injury were tried with *Gmelina arborea* and teak stumps—stripping about one-third of the bark and bruising with a hammer.

The stumps were planted in pits with decayed leaf mould in order to approximate more to forest soils, probably more favourable for bacterial or fungal attack than the experimental garden soil.

Average heights and survival per cent at end of growing season.

Species.	Control.	Bark stripped.	Bruised.
	Ins.	Ins.	Ins.
Gmelina with leaf mould .	28±1·06 100%	30·3±1·27 100%	28·6±1·27 100%
Teak with leaf mould . .	10·2±0·60 100%	11·1±0·61 100%	10·2±0·53 86%
Teak without leaf mould .	9·2±0·54 91%	10·8±0·77 89%	7·9±0·53 91%

The hardiness of stumps is further substantiated. The addition of leaf mould made no appreciable difference in survived per cent, but stimulated height growth somewhat.

(*j*) *Storage of stumps before planting* (Expt. 31).—250 teak stumps made on 3rd July 1931 were planted in comparable lots of 50 stumps after an exposure of 0, 3, 5, 9 and 13 days to sun, rain and wind on a brick floor. At the end of the growing season, the record was as follows :—

Length of storage.	Control.	3 days.	5 days.	9 days.	13 days.
Average height in inches.	12·8±0·67	11·8±0·70	10·1±0·64	10·3±0·50	9·4±0·74
Survival per cent	98	98	94	92	94

As found in the experiments of previous years, storage for several days makes no significant difference in survival or development.

The 1930 experiment with storage 1, 2, 3, 5 and 7 days unwatered *in the shade* shewed the following survivals in December 1931 :—

90, 90, 88, 88, 82% respectively, with no significant differences in average height.

(*k*) *Early planting of stumps without irrigation in cleared lines* (Expt. 61).—This was done with teak. Eleven sets were put out fortnightly beginning from end of January to the break of the rains. This is a repetition of a 1930 experiment and the results obtained are as follows :

Average height and survival per cent at the end of the first December with rainfall data in inches during the preceding fortnight.

Year of Expt.	Middle of January.	End of January.	Middle of February.	End of February.	Middle of March.	End of March.	Middle of April.	End of April.
1930 .	8 8±1·05 36	0 4±0 00 28	10·7±1·83 20	8·4±1·95 20	0 1±1·45 28	8·2±1·27 32	9 8±1·22 28	6 8±0 03 20
	2·0	0 8	3·1	0·1	0 8	..	0 7	0·4
1931 .	.. ..	14·0±2·36 12	11·3±2 71 16	0 0±1·09 16	11·6±1·70 20	11·0±1·81 16	5·0±0 4	11·0±2 36 12
	..	0 2	2·4	2·1	1·5	0 9	0 1	0·0

Year of Expt.	Middle of May.	End of May.	Middle of June.	End of June.	Middle of July.	End of July.	Middle of August.	End of August.
1930 .	9·6±0 89 68	11·1±0·72 92	17·5±1·25 100	10 1±0 51 100	5·6±0 34 80	1·0±0·21 64	2 2±0·14 48	1·6±0 11 28
	0·7	0·5	1·4	4·6	10 6	24·7	11·3	4·6
1931 .	5 8±0 7 20	6 8±0 5 36	7·1±0 58 92	5·7±0·31 92	.. ..	.. ..	.. ..	.. ..
	1·0	0·1	0 0	1·6	5 2	9 2	12·0	10 9

It will be seen that in both years about a quarter of the stumps planted early in the year have survived, but in 1930 with favourable winter rain and monsoon, the monsoon planting is by far the better as regards height attained by the end of the season, whereas in 1931 with favourable winter rain but a very dry summer and late and feeble monsoon, the January planting has given twice the average height of the best monsoon planting. This experiment is being repeated in 1932 and probably again in 1933.

(*l*) *Number of plants per patch.*—An experiment with *Gmelina* was started, earlier experiments have all been unsatisfactory for various reasons.

(*m*) *Branch cuttings* (Expt. 32).—Propagation by branch cuttings of *Bombax malabaricum*, *Eugenia jambolana* and *Lannea grandis* was tried. Planting was done on 18th June 1931 after a shower of rain. The monsoon commenced on 1st July. Practically all the cuttings failed. The best season has not yet been satisfactorily determined.

(*n*) *Twig cuttings* (Expt. 76).—An experiment has been begun to raise plants from small stem cuttings of species which give difficulty in sowings, on lines found successful in England.

(*o*) *Comparison of nursery stock and natural seedlings* (Expt. 56).—*Eugenia jambolana* and *Bauhinia variegata* were transplanted in July

1931; with the former there is no difference in results, but with the *Bauhinia* the survival per cent is less than a third and height only half for the jungle transplants.

Species.		Average height.	Survival per cent in December.
		Ins.	
Eugenia jambolana	Nursery grown . . .	3·8±0·14	94
	Forest grown . . .	3·4±0·16	90
Bauhinia variegata	Nursery grown . . .	23·7±1·29	68
	Forest grown . . .	11·8±1·50	20

(*p*) *Comparison of nursery and forest stumps* (Expt. 46).—*Dalbergia sissoo* was tried, and the forest stumps only gave ⅓rd the survival of the nursery stock but the same height growth.

	Height in December 1931.	Survival %
From nursery	12·6″±0·73	98
From forest	11·1″±1·14	61

(*q*) *Comparison of sowings, transplants and stumps* (Expt. 53).—*Terminalia tomentosa* and *Acacia catechu* were used in July 1931.

Average height in inches at the end of the season :—

Species.	Entire.	Stumps.	Sowings.
Acacia catechu	7·7±0·34 81%	10·4±1·16 34%	4·8±0·30 90%
Terminalia tomentosa . . .	3·8±0·22 96%	7·2±0·37 92%	3·5±0·17 90%

Acacia catechu in 1930 gave 72 per cent and 32 per cent survival per cent at the end of the first season for stumps and transplants respectively—the difference in the two years being presumably due to the different weather conditions. For the *Terminalia*, survivals are similar by all methods but the stumps lead by 100% in height.

(*r*) *Soil working between lines* (Expt. 58).—An experiment to study the effect of soil working between plants on their future growth was laid out in October 1929 in a teak plantation and has now given definite results. The soil worked plants after two workings of the soil gave a difference of +0·5″±1·85″ at the end of the next growing season, the

initial heights having been proved comparable. The gain is too small to justify the cost, which is estimated at Rs. 40 per acre. The experiment is being repeated in another compartment with teak plants.

(*s*) *Araucaria and Casuarina plantations* (Expt. 68).—An area of $\frac{1}{3}$ acre was planted with 160 *Araucaria cunninghamii* plants raised in pots. *Casuarina*, both infected and uninfected, which was raised for Mr. Blake's experiment on nodule formation, was put out in small plots to observe the subsequent growth.

(*vii*) *Nursery work.*

Stock was raised for various species for use in the Demonstration Area and some experiments were carried out, *viz.* :—

(*a*) *Manuring of nursery beds.*—(Expt. 16).—The relative value of farmyard, artificial farmyard, green and chemical manures was tested with teak (Mysore) :—

Kind and amount of manure per bed 35′ × 5′.	% casualties replaced after 12 days.	Survival % at the end of the season.	Average height.
			Ins.
Farmyard 16 baskets . . .	7	83	7·6±0·18
„ 32 „ . . .	7	80	8·4±0·23
Artificial farmyard 16 baskets . .	10	92	7·3±0·16
„ „ 32 „ .	11	82	9·8±0·30
Control	8	92	5·7±0·11
Green (Lucerne)	25	92	5·9±0·12
Sodium nitrate, 8 oz. in 4 applications	14	98	6·1±0·12
Ammonium sulphate, 8 oz. in 4 applications.	11	85	7·2±0·16

It will be noted that all manured beds significantly exceeded the control except for the green manure. Easily the best height was obtained with the use of artificial farmyard manure made from weeds and similar green refuse. Sodium nitrate did not give the stimulus expected but apparently appreciably reduced casualties. The experiment will be repeated another season to check these results.

(*b*) *Nursery bed shades* (Expt. 14).—Five types of shade were tried on *sal*. After the first winter no appreciable difference was noticed between the several shaded beds but the unshaded control showed poorer development and a greater number of casualties than the shaded ones

An important point came up with regard to the use of shades as frost protection for teak, in that strong indications were found that by preventing circulation they had greatly increased frost damage instead of reducing it. Under local conditions free air circulation would appear to be the chief matter to attend to.

(c) *Weed control in nurseries* (Expt. 45).—Paper mulch and weeded beds were compared with an unweeded control for teak of Burma origin :—

—	Survival per cent (December 1931).	Average height in inches.	Dry weight of weeds.
(A) Paper mulch	88	7·3±0·13	4·9 lb.
(B) Weeded	90	8·4±0·13	11·0 lb.
(C) Unweeded	82	7·3±0·13	9·5 lb.

The mulched lines appear little better than the unweeded on the height measurement, but are actually much more sturdy. The mulch on this test does not confer enough benefit to justify its cost.

(*viii*) *Miscellaneous.*

(a) *Effect of Tephrosia candida on the soil moisture and the growth of plants* (Expt. 64).—An experiment was laid out in September 1930 in a teak plantation of 1927 with *Tephrosia* sown in 1929. The *Tephrosia* was removed in some strips and retained in others. Soil samples taken on 25th September, 10th and 25th October from depths 6", 12" and 18" showed no significant difference between strips with and without *Tephrosia*. Further soil samples were taken on 3rd April, 1st, 9th, 16th, 25th June and 2nd July and these still showed no significant difference though the moisture per cent was somewhat higher during April and somewhat lower during June-July for the area without *Tephrosia*.

Height measurements on the teak plants showed a superior growth of teak with *Tephrosia*, amounting to 13·0"±3·65 on a height of about 8 feet, the plants having been proved comparable in height at the time of laying out the experiment. This experiment was undertaken to check a result reported by one of the provinces.

(b) *Nitrogen fixing by Casuarina.*—An experiment to determine whether *Casuarina equisetifolia* can form root nodules in sterilised soil and whether the nodules result in gain in nitrogen content and general growth was laid out in April 1930 by Mr. Blake of the Imperial Forestry Institute. Mr. Blake had to leave before concluding the experiment which was finished for him and all the necessary data and the material finally sent to him. A very definite conclusion was reached and is expected to be published soon.

(c) *Period of height growth of bamboos.*—A minor experiment carried out to check the statement that the height growth of bamboos is not complete in one season, proved that the growth is in fact completed in one year. No growth whatever was found in the second year in *Dendrocalamus strictus.*

(d) *Dying back of Gmelina* (Expt. 63).—All the many scattered lines of *Gmelina* in the Experimental Garden have died off during the last two years, the cause being difficult to determine. A note was published in the '*Indian Forester*', asking if others had had similar trouble but apparently no one has. The Mycologist now believes the mortality to be due to a fungus and has it under observation ; the trouble has spread to all the plantations of the Demonstration Area and 100% mortality is expected there also.

(e) *Cover crops.*—The root systems of 1, 2 and 4 year old *Tephrosia* growing with 1, 2 and 6 year old *sal* and 1 and 4 year old teak, were studied by digging pits and washing away the earth with a syringe.

In the case of one-year-old *Tephrosia* and *sal*, it was found that the *Tephrosia* roots had gone down to 6 ft. or twice the depth reached by the *sal* roots. Two-year-old *Tephrosia* and *sal* had their roots more than 8′ deep, the *Tephrosia* roots being stronger and longer than *sal.* In both these cases, there was no interlacing of *Tephrosia* and *sal* roots, although the lines were only about one foot apart.

In two- and four-year-old *Tephrosia* with 6 year-old *sal*, the roots of both went a good deal below 5 feet and the side roots were found to interlace in the upper soil to a depth of 2 feet but not deeper.

One-year-old *Tephrosia* and teak (stumps) raised with irrigation had their roots down to 6′, the *Tephrosia* having its roots even deeper than the teak. In the upper soil there was some interlacing as in the last mentioned example with *sal.* Two-year-old *Tephrosia* and 4-year-old teak had their roots growing separately and equally down, and again interlaced down to a depth of 2′.

The occurrence and distribution of the *Tephrosia* root nodules were found to vary considerably. In some cases they were found as deep as 5 feet whilst in others there were none below 1½′ and no explanation can be suggested at present ; they are relatively insignificant in size.

Systematic experiments with *Tephrosia purpurea* and *Indigofera endecaphylla* have been commenced, whilst investigations on *I. tinctoria* and *Leucaena glauca* are being continued, as well as those with *Tephrosia candida.* It is too early to arrive at definite conclusions as to the value of these cover crops.

(ix) *Reclamation and afforestation.*

Stocking the Demonstration Area of about 200 acres was nearly completed this year, 15 acres being planted up or sown, leaving about 2 acres to be stocked, apart from the possibility that the 14 acres of *Gmelina* will have to be taken in hand again.

(*a*) *Sal working circle.*—4·4 acres were sown with Hoshiarpur, Gorakhpur large-seeded, Gorakhpur small-seeded, and Haldwani origins. Patching was done in Lansdowne area.

(*b*) *Pinus longifolia.*—8 acres were sown with Nainital, Rawalpindi, Almora, Hazara, Lansdowne and Chakrata origins.

(*c*) *Rosewood working circle.*—1·2 acre (cpt. No. 15) was planted up with stumps and some casualties in C.18 were replaced.

(*d*) *Teak working circle.*—1·5 acres were done with stumps in the Coorg, Jhansi, Central Provinces and Gorakhpur areas.

II.—Statistical Work.

The new Statistical Code was issued early in the year as the second volume of the Silviculture Research Manual for use in India, and may be regarded as a further step in the standardisation of our methods of measurement, etc., which is most important for continuous improvement of the statistical basis of our working plans.

(i) *Yield tables.*

Revision of the existing Yield Tables for deodar has been taken in hand. It is hoped to compile the revised tables separately for different thinning grades despite the paucity of the data; the figures so obtained will be of a purely tentative nature, but it is hoped they will be found of considerable practical utility for comparing the yield from crops under different thinning treatment and in considering thinning grade in relation to minimum exploitable diameter and rotation.

For the measurement of sample plots in the Punjab, a party under the Statistical Assistant toured during May-June 1931 in Kulu and Seraj Divisions. To the 13 old plots which were remeasured, 31 permanent and 1 temporary plots were added. In these plots the thinnings were examined with a numerical check as prescribed in the Statistical Code.

The records of 214 sample plots, of which 88 were new plots and 126 were remeasurements, were received for computation during the year.

The distribution of these plots, by provinces, was as follows :—

Province.	No. of new permanent sample plots.	No. of old permanent sample plots remeasured.	No. of temporary plots.
Bengal	28	..	..
Burma	3	37	..
Central Provinces	..	6	..
Madras	..	19	..
Punjab	..	7	2
United Provinces	8	44	..
Kashmir	14	..	..
Forest Research Institute . .	32	13	1
TOTAL .	85	126	3
GRAND TOTAL .	..	..	214

The following table shews the present distribution of permanent and temporary sample plots by species and provinces :—

Statement showing by species the distribution of sample plots, permanent and temporary, in different provinces of India, including Burma.

Species.	Number of permanent sample plots in each province (excluding those abandoned.)												Number of temporary sample plots in each province.							Grand total.
	Andamans.	Assam.	Bengal.	Bihar and Orissa.	Burma.	Central Provinces.	Madras.	N. W. F. Province.	Punjab.	United Provinces.	Kashmir.	Total.	Bengal.	Central Provinces.	Madras.	N. W. F. Province.	Punjab.	United Provinces.	Total.	
1. *Shorea robusta*	..	..	40	91	..	39	10	..	..	134	..	314	..	5	12	..	..	36	53	367
2. *Cedrus deodara*	..	..	..	..	..	..	..	..	75	40	13	128	..	..	..	..	37	25	62	190
3. *Pinus longifolia*	..	..	..	..	..	2	..	3	30	52	..	87	..	..	..	4	8	56	68	155
4. *Pinus excelsa*	..	..	..	..	..	..	..	9	21	14	1	45	..	..	..	5	35	6	46	91
5. *Tectona grandis*	3	1	11	13	228	38	46	..	..	5	..	345	..	12	..	..	..	1	13	358
6. *Dalbergia sissoo*	..	..	..	..	..	..	..	..	34	27	..	61	..	..	..	..	2	7	9	70
7. Other species	6	16	102	27	74	14	13	..	4	91	..	347	10	26	11	..	5	9	70	417
Total	9	17	153	131	302	93	69	12	164	363	14	1,327	10	43	23	9	87	140	321	1,648

The sample plots for the first six species of the above table comprise 75% of the total number of plots existing for all species; coniferous species account for 27%, *sal* and teak for 22% each, and *sissoo* for the remaining 4%.

With 228 teak sample plots in Burma alone, out of the total number of 358 together in India and Burma, the largest number of sample plots for a single species is reached in that province. Unfortunately the older age classes are unavoidably poorly represented.

The following statement shows the position as regards sample plots for the species listed by the Silvicultural Conference 1929 as requiring yield tables. Only 10 plots were added during the year so that progress is slow.

Species.	Assam.	Bengal.	Bihar and Orissa.	Burma.	Central Provinces.	United Provinces.	Total.	Added since March, 1929.
Acacia catechu	..	..	..	2	..	7	9	3
Acacia arabica	..	..	..	..	..	..	..	..
Alnus nepalensis	..	8	..	..	..	..	8	7
Casuarina equisetifolia	..	..	9	..	.	..	9	..
Cryptomeria japonica	..	9	..	..	..	..	9	8
Dalbergia latifolia	..	..	..	..	..	1	1	1
Eugenia jambolana	..	..	..	..	..	8	8	4
Gmelina arborea	2	11	2	8	..	2	25	6
Michelia champaca	..	4	..	..	..	..	4	1
Michelia excelsa	..	1	..	.	..	..	1	1
Quercus incana	..	..	..	..	..	31	31	1
Terminalia myriocarpa	1	6	..	..	..	..	7	3
Terminalia tomentosa	..	1	10	9	1	8	29	2
TOTAL	3	40	21	19	1	60	144	37

The position as regards the total number of sample plots maintained in the last 3 years is as follows:—

No. of plots in	1929-30	1,189
Ditto	1930-31	1,246
Ditto	1931-32	1,327

The above figures show an increase of 81 permanent sample plots during the year of which 33 were laid out by the Forest Research Institute.

Computations were done for the record number of 444 sample plots, the number of sample plots dealt with in the previous year being only 288. This was mainly due to the staff of the Statistical Section remaining at headquarters for most of the year on account of restricted touring.

(*ii*) *Volume tables.*

A party with the Statistical Assistant toured in November-December in West and South Chanda Divisions of the Central Provinces with a view to collecting single tree data for *Bombax*. The data collected consists of stump analysis done on 64 trees, increment borings taken on 169 trees (676 borings), girth diameter measurements on 101 trees, and standard volume measurements on 114 trees. It has not yet been possible to compute and compile these field measurements. In addition, a sample plot was laid out in the mixed unevenaged forest of *Pterocarpus marsupium*, etc.

Work on the compilation of provisional standard and commercial volume tables by height and diameter classes was begun for *Holoptelea integrifolia* and *Trewia nudiflora* and will shortly be completed. Field data collected by Madras were received for computation and compilation as local commercial volume tables. Numbers and species were as follows :—

1. *Lagerstroemia microcarpa* 799 trees. 2. *Tectona grandis* 527 trees. 3. *Terminalia paniculata* 2,529 trees. 4. *Terminalia tomentosa* 217 trees. 5. *Xylia xylocarpa* 860 trees.	Nilambur, Madras.
6. *Dalbergia latifolia* 217 trees. 7. *Pterocarpus marsupium* 327 trees. 8. *Tectona grandis* 1,693 trees. 9. *Terminalia tomentosa* 528 trees. 10. *Terminalia paniculata* 226 trees.	South Coimbatore.

(*iii*) *Miscellaneous.*

The miscellaneous work of this section, consisting of the compilation of stem and stump analysis data, calculation of volumes and the

statistical examination of results, which has been carried out, mostly for the provinces, is as under :—

Nature of work and species.	Locality.	Province.
1. Compilation of stem analysis data for teak.	South Mandla Division.	Central Provinces.
2. Ditto .	North Mandla .	Ditto.
3. Compilation of stump analysis for teak	Ditto .	Ditto.
4. Compilation of single tree data for teak	Betul Division .	Ditto.
5. Compilation of girth-diameter ratio and $\left(\frac{g}{4}\right)^2, \pi r^2$ factor for—		
(i) Silver fir 100 trees . . .	Kulu Division .	Punjab.
(ii) Spruce 299 trees . . .	Ditto .	Ditto.
6. Compilation of standard and commercial data for spruce 62 and silver fir 25.	Ditto .	Ditto.

In addition, 3 experimental plots were laid out in Chhanga Manga for the determination of water losses due to *kana* grass (*Saccharum munja*). 600 soil samples were collected and their moisture per cent determined.

III.—Miscellaneous.

(i) *Photographic Section.*

The output of work during the last 3 years is as follows :—

Year.	Negatives made.	Prints made.	Lantern slides made.
1929-30	1,200	2,420	134
1930-31	1,471	2,680	128
1931-32	1,071	2,661	60
Total at end of 1931-32 .	13,478	5,371	790

Of the new negatives, 112 were taken by the Silviculturist on tour in Bengal and the Punjab, 665 refer to the Timber Testing Section, and 294 new subjects were taken by the Photographer.

The new dark room at New Forest has been further improved and is ow excellently equipped for the work required. The photographer as absent on sick leave several months so that progress with arrears of

work has been slower than was hoped, but the big task of transferring the inconvenient album collection of prints to the systematically arranged standardised file cabinet method is approaching completion. A collection of selected photos added during the year to the Central and Provincial collections was circulated to all provinces.

The Silvicultural specific collection now has 3,205 prints and the general collection 2,166 prints. Despite these apparently large numbers, good photographs of the majority of species and forest subjects are still greatly needed. 225 prints and 37 lantern slides were sent out in response to requests from England and America. Some photographs were as usual used to illustrate departmental progress reports. A stereo camera was acquired at the end of the year as trials shewed that the stereoscope is a valuable aid to recording progress in forest experiments.

(ii) Records.

It is absolutely impossible with the present staff to keep abreast with current forest literature. Heavy arrears have accumulated during the past two or three years and much of the referencing done has been by title only, even where a publication obviously called for critical examination from the Indian standpoint. Similarly, it has been impossible even to start on the check and weeding of the general ledger files, a task that gets more formidable with every month it is postponed. With the loss of the Assistant Silviculturist ascribed to the need for retrenchment, this important side of our activities cannot possibly be kept up to the standard essential to the maintenance of the claim to recognition on international forestry councils gradually won by India during the last decade.

New ledger files were opened during the year to the number of 53 specific and 35 general, the totals now standing at 1,151 and 389.

The library now contains 827 volumes, including 309 of bound periodicals. A list of 83 books added since the Silvicultural Conference of March 1929 was compiled with a brief note on each, and circulated to Provincial Research Officers as required under Resolution 3 of the Conference.

The extent of the records of the branch give some idea of the development and present wealth of information to be weighed and applied. There are thus 827 books, 1.151 specific ledger files, 364 general ledger files, 1,648 sample plot files, 672 experimental plot files, 5,371 photographs and 83 current investigation files. Only those who work with them are aware what a trifle these form in comparison with the needs of Indian forestry. The position would be completely misunderstood if these numbers were interpreted as indicating that it is time to call a halt,

for the real need is the earliest possible filling of the vast lacunae that remain in our information on almost any selected item.

(*iii*) *Museum.*

The large scale models of silvicultural systems take a long time but they are generally admitted to be the best thing of their kind hitherto prepared. The deodar forest under the selection system is complete except for a few details and work has begun on conversion from irregular selection forest to the uniform with *taungya* operation. As pine forest under the compartment shelterwood system, an irrigated plantation with coppice and coppice with standards, and a forest nursery have already been done.

(*iv*) *Staff and Touring*

Owing to lack of funds very little touring was done. A statistical field party under the Statistical Assistant toured for 8 weeks in Kulu and Seraj measuring and laying out sample plots and a party visited North and South Chanda in the Central Provinces mainly to collect data for *Bombax*. The Silviculturist toured for 3 weeks in January 1932 in North Bengal with the Conservator and Silviculturist, mainly inspecting experimental plots connected with thinning and burning in the plantations. He also made a flying visit to the Sunderbans in connection with the new working plan for the forests there.

Whilst on leave, the Silviculturist visited the forest research centres of Central Europe and made a tour of the experiments under the research staff of the British Forestry Commission. A report was submitted to the High Commissioner concerning the bearing of what was seen on Indian problems, and this report has since been circulated to those concerned in India.

CHAPTER III.

BOTANY BRANCH.

Systematic Botany.—A certain amount of progress has been made with Duthie's Flora and 59 out of 102 genera of grasses have been finished. A new bamboo and a new species of *Diospyros* were described in the '*Indian Forester.*' The descriptions of 4 new species of shrubs from Burma were also published during the year. An article on the name changes proposed in the case of important Indian trees appeared in the '*Indian Forester*' for October 1931. The preparation of this list occupied a great deal more time than had been anticipated when it was started as the changes are numerous and occur in very scattered publications.

Tours.—Owing to the necessity for cutting down expenses as far as possible only one tour of about 3 weeks duration was made to the forests of Northern Bengal during the year. The curtailing of touring is making it difficult to maintain our exchanges with foreign institutions as we have little to offer in return for contributions.

Identification of specimens.—Four hundred and twenty seven specimens were identified during the year mainly for Forest Officers. In addition to these over 100 specimens were identified for the Silviculturist. Of the specimens identified 68 were grasses sent in by Forest Officers engaged on ecological investigations.

Herbarium.—2,719 sheets were added to the herbarium during the year. The principal contributions were obtained by exchange from the Imperial University, Tokyo, Japan; Arnolds Arboretum; Gray Herbarium; Botanic Gardens, Leningrad: Natural History Museum, Stockholm, and from the Forest Botanist, Burma. A bulletin giving a short account of the Herbarium was published during the year.

Arboretum.—The arboretum has been steadily added to but many plants have disappeared. Some of the casualties are unavoidable and due to climatic causes but others are due to insects. *Cassias* suffer greatly from caterpillars, the more vigorous species such as *C. javanica* soon recover but *C. sieberiana* and *marginata* appear to be unable to cope with constant defoliation following a good deal of damage from winter cold. Defoliation by a beetle makes it practically impossible to grow *Cordia caffra* and a scale insect has been steadily killing off *Persea indica*, the same species apparently having killed all our plants of *Acronychia baueri*. The *malis* make no attempt to remove caterpillars eating plants and look upon such casualties as normal and inevitable.

The collection now contains a number of interesting specimens more or less established. We have *Hydnocarpus wightianus* and *Taraktogenus kurzii* sources of *chaulmugra* oil. Neither thrives, however, in Dehra Dun. *Casimiroa edulis* does well in Dehra Dun and should become popular as a fruit tree. *Moringa aptera*, the source of ben oil, has flowered for the first time. *Bolusanthus speciosus* is an ornamental free-flowering tree but unfortunately the flowers are rather ephemeral. *Acrocarpus fraxinifolius* is a quick-growing ornamental tree which should be suitable as a shade tree in tea gardens. *Enterolobium timbouva* has reached a girth of 31 inches in 7 years from seed. It has much the same habit as the well-known raintree (*E. saman*) but is much hardier. The raintree has never yet survived a winter in Dehra Dun. *Macaranga denticulata* gives some promise as a quick-growing tree for temporary shade. *Alsecdaphne keenanii* which is said to yield a useful timber is growing vigorously with very straight stem. Both *Alnus nepalensis* and *nitida* are growing well in Dehra in spite of the elevation being so much lower than their normal habitat.

Supply of seeds.—Over 3,500 lbs. of seeds were supplied during the year of which 2,400 lbs. was *Pinus longifolia* for the Union of South Africa. Seeds were also sent to the Forest or other Government Departments in Sierra Leone, Nigeria, Tanganyika, Uganda and the Sudan. Ceylon, Java, Sumatra, China, Japan, Australian Commonwealth, Queensland and West Australia were also supplied.

The Seed Exchange List has been revised and offers over 450 kinds of seeds that are easily obtainable from wild plants and those cultivated in the arboretum.

Mycology.

1. *Root disease of shisham.*—Some of the plants which were inoculated with pure cultures of *Fusarium* sp. in 1923-27 are showing signs of infection and the inoculated trees which are already showing wilting stages will be examined for the causal organism and compared with the pure culture with which they were inoculated.

2. *Identification and control of Sal-thicket fungus.*—Preliminary study of this problem was done in 1928-30. No further progress has been made.

3. *Investigation on the life history of Peridermium spp. in India* :—

(*a*) *Peridermium himalayense.—Chir* (*Pinus longifolia*) saplings were inoculated in Kumaon forest in 1928-29 with *Cronartium* sp. on Swertia and some of these are now showing signs of infection. The plants which are showing canker stage have been pathologically examined for the causal organism. Examination of the controlled plots remains to be done in order to study the effect of Swertia eradication on the incident of infection.

(*b*) *Peridermium indicum.*—Morphological study of *Cronartium* fungus on *Ribes rubrum* collected from Kulu has already been made but it has not been possible to do any experimental work during the year under review. It is, however, now proposed to compare the *Peridermium* fungus on *Pinus excelsa* and the *Cronartium* sp. on *Ribes rubrum* from Kulu with those of Kagan and with the European species *Cronartium ribicola*. And in this connection it is also proposed to survey the forests of Jaunsar, Chakrata, where the *kail* rust was first collected by Nisbet in 1894.

4. *Damping off disease in forest nurseries.*—Effects of damping off fungi on seeds grown in sterile conditions were compared with those grown in non-sterile conditions as far as practicable, and for this purpose large number of culture experiments were made on the following species :—*Pinus caribea*, *P. palustris*, *Ailanthus excelsa*, *Dalbergia sissoo*, *D. latifolia*, *Tectona grandis* and *Shorea robusta*. The damping off organisms which attacked *Pinus caribea* and *Ailanthus excelsa* vigorously were identified as *Fusarium* spp. The cultures are maintained for inoculation study during the rains. It is intended to extend these experiments to nursery beds and along with the above species *Terminalia tomentosa* which is a damping species will also be taken up.

5. *Cultural studies of wood-rotting fungi.*—Cultures of several species of *Polyporus*, *Polystictus* and *Fomes* have been added to our collection. The cultures of parasitic fungi which have been isolated from various plants and are directly concerned with the problem under investigation have also increased. It is, therefore, proposed to limit the work on saprophytic woodrots.

6. *Routine works.*—The work of identification and report on specimens has increased considerably during the present year and enquiries from various Forest Departments have been attended to. And considerable time has been devoted to the examination of a large number of teak saplings from Madras grown by root and shoot cutting methods for root and collar rot and die-back of *Gmelina arborea* trees in New Forest from unknown cause. Teaching works of the Indian Forest Service students were done as in the previous years.

CHAPTER IV.

ECONOMIC BRANCH.

Wood Technology Section.

Work in connection with the preparation of "Manual of Indian Timbers" was continued by Dr. H. P. Brown, Syracuse, N.Y., and Mr. R. S. Pearson, C.I.E., Forest Products Research Laboratory, England. It is expected that the Manual will be published in 1932.

1.—Research.

(*a*) The hand lens key for the identification of important Indian sleeper woods, supplemented by X 10 photomicrographs, was completed during the year and is now in the press. This bulletin will be of help to sleeper passing officers of the Railway and Forest Departments, and to others interested in the sleeper-wood trade.

(*b*) "Growth studies in some North Indian forest trees" were continued throughout the year. Results so far obtained indicate the necessity of continuing the work for another year.

(*c*) Research on the anatomical study of woods of the 'Indian Dipterocarps' was continued. The specimens received during the year from different parts of India have been studied. Fresh material is being taken up as it comes to hand, and it will be some time yet before the study is complete.

(*d*) A set of 33 photomicrographs of important Burma timbers was completed, and sent to the press by the Burma Forest Department.

(*e*) Experiments in connection with the improved method of softening micro-blocks in hydrofluoric acid have been continued. With low power blocks, the results obtained were consistently satisfactory. Further experiments are now in progress to determine the possibility of softening high power blocks by the same method.

(*f*) At the request of the Forest Entomologist a study of the anatomical structure of some important Indian woods was taken up to elucidate the relationship between the size of vessels in a wood and its liability to attack by *Lyctus africanus*. This work is progressing satisfactorily.

(*g*) At the request of the Forest Economist, Burma, a study of the woods of three varieties of *Terminalia tomentosa* was started with a view to finding out whether they can be separated macroscopically or microscopically. This research is of interest from a commercial

point of view, for it is quite possible that the three varieties have different values for furniture woods. Other Provinces are also interested in this enquiry.

2.—Identification.

(*a*) Identification of wood :—Many enquiries for the identification of wood specimens were received from the various Branches and Sections of the Institute as well as from Forest Officers, industrial concerns and other Government Departments. 504 specimens were identified during the year.

(*b*) Identification of charcoal :—In addition to the routine charcoal identification work for the Minor Forest Products Section, two lots of charcoal received from Dhilwan, North Western Railway, were identified.

3.—Examination for fungus.

Various enquirers sent wood specimens, suspected of having been attacked by fungus. The number of specific enquiries replied to in this connection was 69.

4.—Special enquiries.

Several special problems were taken up on behalf of the officers of the Institute and Forest Officers in the Provinces. Enquiries were also received from outside sources such as :—

(*a*) The Superintendent, Rifle Factory, Ishapore.

(*b*) The Timber Advisory Officer, Railway Board.

(*c*) Railway Officers.

(*d*) The Chief of Division of Botany, Saigon, Siam.

(*e*) Messrs. Gosperlin, Chicago, U. S. A.

In addition to these, a quantity of technical information was supplied to other enquirers from various parts of India.

5.—Accumulation of anatomical data.

In course of routine work, a large number of data sheets was filled up and filed for future reference.

6.—Collection of authentic wood specimens.

(*a*) In India :—For our authentic collection we received 91 wood specimens from different parts of India.

(*b*) From abroad :—This year 23 wood specimens have been received from the Forest Department, Singapore, to whom our thanks are due for helping us to make a complete set of the commercial timbers of the world.

7.—Distribution of wood specimens.

In response to requests from abroad and various parts of India, over 900 samples of timber were sent out to interested enquirers.

8.—General.

The usual course of Wood Technology was given to the Indian Forest Service students.

Short courses in wood identification and wood structure were given to officers deputed to this Section. Keys for the identification of timbers were made by the Wood Technologist to meet their respective requirements.

TIMBER TESTING SECTION.

Staff.—The system of interchange between Laboratory and Computing staff inaugurated last year was continued, till each member of the staff obtained instruction in all branches of the work for which his education and abilities suited him.

Owing to the reduction of staff, however, it was found necessary, in order to maintain efficiency, to conduct the work intermittently by concentrating all available personnel for some time on mechanical tests, then stopping mechanical tests for a time and concentrating on computations.

New investigations.

During the year special studies were started to investigate fastenings suitable for conducting tension tests on small wood samples, and to determine the strengths of bamboos which have been stored under varying conditions. The former enquiry was carried to its conclusion and a suitable fastening for small specimens was devised. The mechanical testing of bamboo specimens has also been finished and the results are being computed and analysed.

Work continued during the year.

The output of results from routine testing was greatly reduced by the reduction of staff and also by necessary economy in material and power. Despite this, satisfactory progress has been made under the following headings :—

Project 1.—Standard tests of small clear specimens.

Project 2.—Tests of timber in structural sizes.

Tests of plywood in co-operation with the veneers sub-section.

Tests of tea boxes in co-operation with the veneers sub-section.

In addition to the above, a special study of shrinkage determinations, inaugurated last year, was continued, and useful results obtained. Over 21,000 observations were recorded during the year.

A small amount of testing was also done with reference to railway sleepers and in the examination of material from damaged aeroplanes.

Number of species tested during the year.

	Green.	Air dry.	Kiln dry.
Project 1	9	16	11
Project 2	3	4	..
Project 0 under various sub-heads			57
Charcoal briquettes			84 consignments.

Number of species computed during the year.

Project 1	16	20	21
Project 2	4	10	..
Project 0 under different sub-heads . . .			76
Charcoal briquettes			84 consignments.

In the laboratory, over 21,000 mechanical tests and 22,000 physical determinations were made during the year. Arrears in computations were made up and the work of the testing laboratory and computing office is now being kept balanced.

92 technical letters and reports were issued by the Section during the year. This represents a decrease over former years, partly due to the decrease in staff but also largely influenced by the fact that some of the reports were of a more exhaustive nature than formerly and occupied, in consequence, more time. Some of the subjects dealt with are shown in the following lists :—

1. Tea chests.
2. Tea chest fastenings.
3. Tests of spike holding power.
4. Boat building materials.
5. Tool handles.
6. Wood for motor bodies.
7. Wood insulators for overhead power lines.
8. Indigenous substitutes for Lignum-vitae.
9. Wood for umbrella handles.
10. Methods of testing plywood.
11. Woods used in aeroplane construction.
12. Woods used in aeroplane repairs.

13. Woods used in gliders.
14. Woods for police batons.
15. Woods for golf club heads.
16. Woods for sluice gates.
17. Woods for cooling towers.
18. Woods for sporting goods.
19. Floor boards and flooring.
20. Laminated wheels.
21. Picker arms.
22. Furniture.
23. Tests of nail holding ability.
24. Woods for bobbins.
25. Woods for sea walls.
26. Sleepers.
27. Tests of glued joints.

Seasoning Section.

Railway kiln seasoning.

The supervision of the kiln seasoning installation at the East Indian Railway Workshops at Lillooah continued to absorb the attention of the Officer in Charge, Seasoning Section, but not to the same extent as in the previous year, on account of the fact that the necessary alterations and improvements to the kilns had been effected, and the operation of the kilns had been standardised into more or less routine channels. Moreover, due to the general trade depression and the retrenchment policy of the railways, carriage building programmes have been considerably curtailed, which very greatly reduced the demand for timber. The quality of the kiln dried material turned out at Lillooah during the year was very satisfactory, credit for which is chiefly due to Mr. D. P. Saksena, previously Lower Grade Assistant in this Section, whose services have now been permanently transferred to the East Indian Railway. In view of the success achieved at Lillooah in the increased use of kiln dried indigenous timbers other than teak for railway carriage building, it can be anticipated that with a return of normal conditions of trade, other State Railways in the country will go in for seasoning kilns.

Project VII.

The work on the kiln drying of Indian timbers under Project VII has been practically in abeyance during the year, on account of the delay in rebuilding the newly designed seasoning kilns at Dehra Dun

The external blower kilns, which were demolished in October 1930, were only completed towards the end of the year, while the Tiemann Water Spray kilns were dismantled in November 1931. On account of shortage of men, the progress of construction work has been very slow and it is likely that another year may elapse before the alterations to the 3 Tiemann kilns are complete and before the fitting up of the smoke kiln, the building for which was completed by the Public Works Department during the year, is finished.

Out of 35 charges of timber put through the kilns, there were only 12 for Project VII, dealing with 8 timbers, the results for which are tabulated below :—

No.	Species.	Trade name.	Thickness in inches.	Moisture content		Duration days.	Increase in degrade.	Remarks.
				Initial.	Final.			
1	*Machilus* spp. .	Indder wood (Bengal).	1	% 65	% 7	14	% 3·7	Increase in degrade chiefly due to spring and collapse. Liability to the formation of wet pocket in the interior and consequent case-hardening were marked
2	Ditto .	Ditto .	2	101	7	10	2·3	
3	*Dunbanga sonneratioides.*	Ingatti (Bengal).	1	126	11	12	2·6	Chief defect spring. Seasoning successful.
4	*Artocarpus fraxinifolius.*	mundani (Bengal).	1	95	11	16	3·6	Spring, shakes and collapse. Liability to case-hardening.
5	*Artocarpus chaplasha*	chaplash (Bengal).	1	158	8	18	1·6	Spring. Seasoning successful.
6	*Grewia tiliaefolia* .	dhaman (Madras and Bombay).	1½	60	10	28·33	7·5	Increase in original shakes and split knots. Seasons very well otherwise.
7	Ditto .	Ditto .	2½	60	11	45	7·5	
8	*Holoptelea integrifolia.*	Indian elm. (United Provinces).	1	40	9	4	0·4	No appreciable degrade, extremely easy to dry.
9	*Castanopsis* spp. .	Indian sweet chestnut (Assam).	1	52	8	16	12·0	Shakes and split. Initial quality very poor.
10	*Stereospermum chelonoides.*	padri wood (Assam)	1	35	11	5	8·0	Spring and twist. Seasoning easy.

In the kiln drying of Indian hardwoods, specially the refractory species, it has been noticed that in an external blower seasoning kiln, a sufficiently rapid rate of air circulation cannot be attained to dry timbers on a high humidity schedule. With the lower humidities that

have to be employed with a kiln of this type, the surface of wood tends to case-harden, even with repeated high humidity and steaming treatments, and a moisture pocket is formed in the interior. This is very difficult to remove. With an internal fan kiln, it is possible to get a very rapid circulation of air, and the few results that have been obtained with this type of kiln towards the end of the year clearly indicate that the problem of drying refractory hardwoods is nearing solution.

As usual, a lot of material for the wood workshop and the Timber Testing Section was kiln dried, in addition to the work under Project VII.

Air-Seasoning.

On all the eight species tested under Project VII small air-seasoning experiments were also undertaken, a practice which was started during the previous year. The present tests corroborated the results reported last year that for one inch thick planks of most species, a period of two to three months is quite sufficient for proper seasoning under Dehra Dun conditions. Up to date, data on 24 species have been recorded.

The experiments on the air-seasoning of one inch thick planks of *haldu* (*Adina cordifolia*) were completed during the year, but the material has been kept for further observation. The chief results are :—

(i) one inch crossers are sufficiently thick for the proper air seasoning of the timber,

(ii) a pile width of 5 feet is not too wide to make appreciable difference in the rate of drying of planks in the middle of the stack, and

(iii) a foundation of about 18" height is necessary to equalize the rate of drying of timber between the top and bottom of a stack.

The experiments have, therefore, proved the rationality of the air-seasoning procedure recommended previously by the Institute.

The experiment on the seasoning of *Terminalia tomentosa* broad gauge sleepers, after painting the surface with a 50 per cent. solution of glycerine, started at the end of the last year, is still under progress. It has been found that after 12 months' seasoning, the moisture content of sleepers has come down to less than 16 per cent. from an initial moisture content of 63 per cent. Boring tests on 5 sleepers indicate an average moisture content of 11·2 per cent. in the surface layers, and 17·0 per cent. in the interior. The condition of the sleepers is extremely satisfactory, there being very much less cracking and splitting than is usual with this species. Further tests are to be taken in hand in order to find a cheaper material than glycerine for the purpose.

A series of experiments on the seasoning of softwood railway sleepers was carried out in co-operation with the Punjab Forest Department at the Government Timber Depots at Doraha, Dhilwan and Jhelum. The experiments were started in November 1931 and completed in March 1932. The experiments have yielded valuable data on methods of stacking, the period of seasoning required, the top covering of stacks, and the coating of sleeper ends.

The method of close crib stacking has been definitely proved useless for the seasoning of softwood sleepers in the Punjab. Tarring the ends of sleepers has been proved useful in reducing end-splitting. Protection to the sleeper stacks against rapid drying, both on the top and the sides, has been found to be very desirable.

Some interesting results have been obtained with the water seasoning of billets of *Parrotia jacquemontiana* from Kashmir State. The timber is useful for tool handles, but is said to crack badly during seasoning. In order to overcome this difficulty, billets were soaked in water for varying periods before proper air-seasoning was started. After experimenting, it was, however, found that water soaking reduced the toughness of the wood, and was, therefore, not to be recommended. It was further observed that the billets air-seasoned very well if given sufficient care in stacking and sheltering. The presence of bark, and the coating of ends with some moisture retardent composition were also helpful in reducing degrade.

Laboratory tests.—In addition to the usual large number of determinations of moisture content and stresses in wood during the course of drying—the number this year being over 8,400 for moisture determinations and 3,680 for case-hardening tests—an exhaustive study into the shrinkage, collapse and density of *toon* (*Cedrela toona*) was undertaken. This is still in progress. Shrinkage and collapse under various conditions of drying, such as air seasoning, kiln drying and controlled drying under high relative humidity, were determined on 440 planks and scantlings of *toon*, and in more than 1,600 small clear specimens of the same wood. Specific gravity measurements were carried out on more than 800 small test pieces, with a view to finding the variation in shrinkage from the bottom to the top and from the centre to the periphery of a tree. The results obtained are being analysed, and a report will be issued during the coming year. Some of the most interesting features are as follows :—

Collapse in toon.—This was found to occur mainly on the radial face of a board, the pieces from the butt end of a tree being more liable to collapse than those from the top. Further it was noticed that collapse is usually confined to the outer heartwood layers, and that it starts while the wood is still at about 50 per cent. moisture content. The

conditions of drying do not appear to influence it in a definite manner, except in so far that there is a tendency for greater collapse if the relative humidity during the early stages of drying is particularly high. Thick and wide boards appear to be more liable to collapse than thin and narrow ones.

It has been found that steaming at about 100°C for 6 hours removes most of the collapse in *toon*. During the steaming operation the timber gains about 10 per cent. moisture, which is, however, lost after a few days' exposure to the atmosphere. The planks after treatment show a permanent increase in cross sectional area of about 4 per cent. The timber gets darkened, and there is a tendency for collapsed knots to crack badly during the steaming process.

Shrinkage.—It is a matter of common observation that a piece of green wood starts to shrink immediately it is exposed to drying conditions, whether in a kiln or in the atmosphere, and that the total shrinkage is influenced a good deal by the drying stresses produced in the specimen during the early stages of drying. In this way it becomes difficult to compare the shrinkage propensities of two samples of wood dried under different conditions, not knowing the effect of the micro-structure of wood on the shrinkage. To overcome this difficulty, the determination of the so-called "Basic Shrinkage" has been made a standard practice in the Seasoning Section during the past year. Specimens are allowed to dry in a practically saturated atmosphere at room temperature, in a box provided with a fan for rapid circulation of air. It has been found that the pieces dried in this manner do not show any appreciable shrinkage till the Fibre Saturation Point is reached. Corresponding pieces have been dried under various conditions in the kilns or in the atmosphere, and the variation from the "Basic Shrinkage" gives a good method of comparison of the effect of drying on shrinkage of wood.

Specific gravity.—The usual method of determining the volume of a small specimen of wood in a mercury volume-meter is open to the objection that a certain amount of mercury is absorbed by the wood during the process. The absorption is negligible in coniferous woods, but may introduce a serious error in hardwoods. The error can, no doubt, be corrected by a subsequent weighing, but the piece becomes useless for any further test, as it cannot be entirely freed from the mercury held in the capillary spaces. Preliminary tests were carried out with 9 timbers, using the Archimedes principle and water displacement, and it was found that by using a modified formula, which takes into account the amount of water absorbed during the process, the results obtained do not differ appreciably from those obtained with the mercury volume meter, corrected for mercury absorption, while the specimens can be used for further observations on drying and shrinkage. This practice has now been adopted for all determinations of specific gravity.

Shrinkage of planks and scantlings.—Specimens of 10 species were added during the year, making a total of 27 species under observation. The tests will continue for some years.

Enquiries.

About a dozen enquiries were dealt with regarding the design and operation of seasoning kilns, out of which the following are worth mentioning :—

Kashmir State.—Specifications were supplied to the Kashmir Forest Department for a battery of 3 kilns for the drying of Kashmir walnut for furniture manufacture. The work has been held up on account of the prevailing trade depression.

Madras.—Details for a battery of timber drying kilns were sent to a firm in Madras for the kiln drying of timbers for picture framing and moulding industry.

Madras and Southern Maharatta Railway.—An enquiry for an installation of timber seasoning kilns was received from the Madras and Southern Maharatta Railway and is being dealt with. It is possible that this railway may take to kiln seasoning in the near future, if financial conditions improve.

Enquiries were also dealt with on air seasoning, designs for sheds, seasoning of railway sleepers, electric moisture meters, steam bending of wood, dryage of cinchona bark, girdling of trees before felling, etc.

Training.

Two apprentices from the Wood Working Institute, Bareilly, were given a course of training in the practice of kiln drying.

Wood Preservation Section.

(1) *Project IV.*

Work under Project IV is now nearing completion. Most of the possible species have been investigated. A few species remain and are being seasoned for treatment in the near future.

The following sleepers were treated and despatched to the railways concerned for durability trials in the line :—

Species.	No.
Poeciloneuron indicum	138
Terminalia belerica	100

Sleepers of *Anthocephalus cadamba* were also received and treated, but the initial rejection was so high and the condition of the survivals so poor that they were not considered suitable for test in the line.

Several lots of sleepers for preliminary trial were sent in but most of them arrived in a very bad state, owing to fungus and termite attack and they were not treated. Most of these sleepers came from Assam and emphasises the urgency of a comprehensive study being undertaken to prevent fungus attack in sleepers both before despatch from the forests and while seasoning at a treating plant. This question is one deserving of a special enquiry and its importance cannot be too strongly emphasised.

A detailed and exhaustive study of the Powellising process was undertaken during the year, and the first part dealing with the treatment of green sleepers was concluded. Valuable data were collected which will have an important bearing on a proper understanding of the movement of aqueous solutions into timber.

Several charges of mixed sleepers were tried in continuation of the work to determine a composite specification for species which do not occur in sufficient quantity to be treated separately.

The work on the treatment of fir and spruce was continued and concluded with a trial of sleepers obtained directly from the river at Dhilwan. It was found that they cannot be obtained commercially in the condition necessary for complete impregnation, and the position remains where it was, namely that incision is the best compromise. Some experiments conducted on resoaking also gave valuable data on the difficulties likely to be experienced with these species with salt solution treatments.

Work on the impregnation of timber with emulsions showed fairly clearly that this method of application was not likely to be of much importance. The timber acts as ultrafilter and "breaks" the emulsion before it has penetrated to any depth. There is always room for further work in this field, but since there were no indications of any potential possibilities the work was not continued.

(2) *Toxicity tests.*

Work in this field was seriously hampered by the difficulty of keeping fungus cultures free from moulds, and it was decided to concentrate on the work as far as possible during the cold weather. This, however, will not altogether overcome the difficulty, and the need for a special room which can be kept at least temporarily sterilised becomes more and more apparent. The work was discontinued in order to concentrate on other work considered more urgent but in the meantime several sporophores were collected and sent to Kew for identification. Before work in this field can be successfully prosecuted a collection of pure cultures of typical Indian wood destroying fungi will have to be made.

(3) *Graveyard tests.*

The following additions to the graveyard were made :—

54 Untreated specimens for durability tests.

7 New antiseptics.

An examination of the degree of termite attack was made at quarterly intervals throughout the year. Tentative results were tabulated but the drawing of any conclusions was postponed until further data are available. Several important points, however, have been settled.

(4) *Laboratory.*

Various experiments on new methods of treating timber were tried particularly in the utilisation of cheap waxes and synthetic gums. The results were negative. A large number of analyses were conducted in connection with the distribution of arsenic in the experiments on the Powell Process and valuable data obtained. Work was started to determine the toxicity of aqueous and ether extracts of durable timber, but was suspended in order to test the possibilities of a new process of wood preservation introduced by Mr. S. Kamesam, Assistant, Wood Preservation Section, on his return from Europe. Mr. Kamesam, working with Dr. Falck in Germany, studied the fixation of arsenic in wood and found what appears to be a successful solution to the problem. He returned from deputation at the end of November 1931, and tests to verify his results were immediately put in hand and proved successful. In addition the work he did in Germany provided an excellent training in mycological technique and his experience should prove invaluable in continuing the toxicity work noted above.

(5) *Miscellaneous.*

A tour was undertaken by the Officer in Charge to inspect railway sleepers under test in the Indian railways and valuable data obtained.

A large number of bamboos were treated in connection with some work undertaken by the Forest Entomologist and the Officer in Charge, Minor Forest Products Section. This has special application to the prevention of beetle attack in lance staves, etc.

Messrs. Turner Morrison again requisitioned the services of the Officer in Charge for consultation with reference to their new plant for the production of creosote, and later wrote thanking the Institute for the valuable advice and help given.

A comprehensive specification for creosote for use in India was drawn up by the Officer in Charge and adopted by the Government Stores

Department for all Government purchasers. This will replace the old specification which was out of date and not suitable for Indian conditions.

Experiments on the moisture movement in treated wood were concluded and a report issued.

Financial stringency was responsible for some curtailment in the plant work, but some valuable laboratory work was accomplished during the year. The need for a knowledge of the composition of Indian timbers is felt in many directions and should assume a place of first importance in the future.

Wood Workshop Section.

General.

As compared with the previous years' returns the amount of work carried out during the year under review shows a considerable decrease, particularly with regard to supplies of specimens to the Timber Testing Section where there was a fall in demand amounting to 13,118 specimens.

The output from the sawmill was also considerably reduced, as the requirements of the Wood Technology and Seasoning Sections were equally small. Towards the end of the year, the work in the Veneer Sub-Section had also to be slowed down, when the Officer in Charge took over the duties of the Expert Cabinet Maker in addition to his own work.

Wood Workshops.

This Sub-Section followed the usual practice of supplying all other Sections with converted material for research purposes, and also supplied and maintained office furniture, fitments and interior decorations throughout the Institute. This work, which involved 870 separate jobs was of a very varied character including as it did such pieces of work as panelling almirahs, flooring, tables, chairs, file cabinets, card index cabinets, showcases, screens, clockcases, callipers, boxes, tea chests, racks, switch boards, drawing boards, tee squares, doors, windows, picture frames, rods and brackets, staircases, name boards, machine guards, kiln fitments, etc.

As explained above, the supply of routine test specimens was interrupted, but nevertheless the Timber Testing Section was supplied with 20,494 test specimens and the Wood Technology Section received 978

hand specimens and 50 Gamble specimens. Some of the species dealt with are enumerated below :—

1. *Buxus sempervirens.*
2. *Tectona grandis.*
3. *Artocarpus hirsuta.*
4. *Cedrus deodara.*
5. *Anogeissus latifolia.*
6. *Carallia integerrima.*
7. *Terminalia manii.*
8. *Shorea robusta.*
9. *Grewia tiliaefolia.*
10. *Dalbergia sissoo.*
11. *Terminalia procera.*
12. *Chickrassia tabularis.*
13. *Mesua ferrea.*
14. *Vatica lanceaefolia.*
15. *Berrya ammonilla.*
16. *Hopea parvifolia.*
17. *Diospyros bourdilleni.*
18. *Cinnamomum inunctum.*
19. *Pinus longifolia.*
20. *Pinus excelsa.*
21. *Xylia dolabriformis.*
22. *Sageraea listeri.*
23. *Dipterocarpus turbinatus.*
24. *Machilus gammieana.*
25. *Acacia catechu.*
26. *Lannea grandis.*
27. *Hopea cordifolia.*
28. *Abies pindrow.*
29. *Artocarpus chaplasha.*
30. *Endospermum malaccense.*
31. *Acrocarpus fraxinifolius.*
32. *Anisoptera glabra.*
33. *Aegle marmelos.*
34. *Melia azadirachta.*
35. *Pentace burmanica.*
36. *Bursera serrata.*
37. *Dalbergia latifolia.*
38. *Adina cordifolia.*
39. *Terminalia tomentosa.*
40. *Albizzia procera.*
41. *Ougeinia dalbergioides.*
42. *Dipterocarpus indicus.*
43. *Terminalia bialata.*
44. *Diospyros marmorata.*
45. *Kayea assamica.*
46. *Shorea assamica.*
47. *Hardwickia pinnata.*
48. *Shorea tumbuggaia.*
49. *Albizzia lebbek.*
50. *Pterocarpus dalbergioides.*
51. *Maba buxifolia.*
52. *Dipterocarpus macrocarpus.*
53. *Gluta travancorica.*

Special reports in connection with the working qualities of 23 species were put up. This work requires careful attention, as the personal factor enters so much into it. Knife bevels, saw teeth and feed speeds etc., require to be altered and adjusted with different species to obtain a desirable and economic finish. The species reported upon were :—

1. *Dipterocarpus costatus.*
2. *Dipterocarpus alatus.*
3. *Myristica attenuata*
4. *Anisoptera glabra.*
5. *Gmelina arborea.*
6. *Cinnamomum inunctum.*
7. *Quercus lamellosa.*
8. *Cupressus torulosa.*

9. *Bassia latifolia*
10. *Carapa moluccensis.*
11. *Juglans fallax.*
12. *Hopea glabra.*
13. *Careya arborea.*
14. *Stereospermum suaveolens.*
15. *Machilus macrantha.*
16. *Canarium strictum.*
17. *Pterospermum acerifolium.*
18. *Cynometra polyandra.*
19. *Sonneratia apetala.*
20. *Dipterocarpus turbinatus.*
21. *Altingia excelsa.*
22. *Lophopetalum wightianum.*
23. *Terminalia chebula.*

Enquiries in connection with wood working and related subjects other than veneers, plywood and glues, were received from the undernamed:

Andhra Scientific Co., Masulipatam, South India, regarding suitable timber for laboratory apparatus.

Manager, C. &. W. Shops, E. I. R., Alambagh, Lucknow, regarding utilization of mill residue.

E. Mitter, Esqr., Durmahatta Street, Calcutta, regarding splints used by jewellers and watchmakers.

The High Commissioner for India, London, regarding working qualities of *Terminalia procera* and *Parishia insignis.*

Messrs. A. C. Sawhney & Sons, Lahore, regarding *Eugenia jambolana* for coach building.

Khem Chand Rajkumar, Jullunder City, regarding production of 1,000 folding chairs per day.

Timber Trading Agency, Calcutta, regarding suitability of Burma padauk for the building of carriage bodies and furniture, etc.

The British Paint & Lacquer Co., Ltd., Oxford, England, regarding Bripal cellulose finishes for wood.

H. L. Shrager, Esqr., through Officer in Charge, Timber Testing Section, regarding non-splitting nails.

Bahraich Exhibition regarding a collection of exhibits made and supplied.

Lord Reay Industrial Museum, regarding a collection of exhibits made and supplied.

Chief Mechanical Engineer, G. I. P. Railway, Parel, regarding working qualities of *Artocarpus hirsuta.*

A course of lectures was delivered to the Senior Indian Forest Service students on sawmills, wood working and plywood.

Sawmill.

This Sub-Section converted 342 logs, as compared with 534 logs the previous year. These logs were dealt with on behalf of the Timber Testing, Seasoning, and Wood Workshop Sections and comprised 54 species.

In addition to the above, 800 paving blocks, 500 crossers, 200 tent pegs were made and 2,400 bamboos were cut up for use in the Paper Pulp Section.

Veneers and Plywood.

Tests under Project VIII were carried out on the following species :—

Plywood—

1. *Dalbergia sissoo* (Punjab).
2. *Dipterocarpus indicus* (Mysore).
3. *Artocarpus hirsuta* (Bombay).
4. *Pinus longifolia.*
5. *Cedrela toona* (United Provinces).
6. *Dalbergia latifolia* (S. Coorg).
7. *Artocarpus hirsuta* (Madras).
8. *Chickrassia tabularis* (Assam).
9. *Dysoxylum binectariferum* (Burma).
10. *Calophyllum tomentosum* (Madras).
11. *Canarium strictum* (Madras).
12. *Cullenia excelsa* (Madras).
13. *Terminalia paniculata* (Madras).
14. *Terminalia belerica* (Madras).
15. *Calophyllum tomentosum* (Mysore).
16. *Acer campbellii* (Bengal).
17. *Albizzia procera.*
18. *Terminalia myriocarpa* (Bengal).
19. *Adina cordifolia* (Bombay).
20. *Bombax malabaricum* (United Provinces).
21. *Dalbergia latifolia* (Bombay).
22. *Pterospermum acerifolium* (Bengal).
23. *Amoora wallichii* (Assam).
24. *Machilus macrantha* (Madras).
25. *Vateria indica* (Madras).
26. *Hopea parviflora* (Madras).
27. *Duabanga sonneratioides* (Assam).

Tea chests.—Tea chests of the following 9 species were made and tested : -

1. *Duabanga sonneratioides.*
2. *Canarium strictum.*
3. *Bombax malabaricum.*
4. *Terminalia myriocarpa.*
5. *Artocarpus hirsuta.*
6. *Machilus macrantha.*
7. *Vateria indica.*
8. *Adina cordifolia.*
9. *Acer campbellii.*

Tea chests of *bonsum* (*Phoebe hainesiana*) were made up, loaded with tea and despatched abroad. A report is awaited. This practical test was carried out with the help of a firm of tea brokers in Calcutta.

Standard Glue Shear tests were made and completed in conjunction with the following species :—

1. *Terminalia bialata.*
2. *Dalbergia sissoo.*
3. *Pinus excelsa.*
4. *Cupressus torulosa.*
5. *Abies pindrow.*
6. *Dalbergia latifolia.*
7. *Pterocarpus* spp.
8. *Cedrus deodara.*
9. *Pinus longifolia.*

Enquiries in connection with plywood and glues were received from the undernamed :—

Headmaster, Government Wood Working Institute, Jullunder City, regarding casein cements.

Inspector of Gun Carriages, Jubbulpore. regarding suitability of Casco casein glue for the making of laminated wheels.

The Association for the development of Swadeshi Industries regarding the establishing of plywood factories in India.

A Roller & Co., Berlin, Germany, regarding establishing plywood factories in India.

Bird & Co., Calcutta, regarding casein cements.

Plummer Bros. & Co., Bombay, regarding casein cements.

Divisional Forest Officer, Timber Research Division, Rangoon, regarding plywood of *Cedrela toona* and *Dysoxylum binectariferum.*

Bird & Co., Calcutta, regarding plywood of *Pterospermum.*

Lazarus & Co., Calcutta, regarding gluing processes.

Panels of matched laurel veneers on laminated cores are being made and fitted in the board room of the Forest Research Institute. These panels are experimental and will be kept under observation and their future behaviour recorded. Although only partially completed they have every appearance of making a very fine display. Observation is also being kept on the veneered lamin panels in the Forest Economist's room and also on the tables made of this construction in the library.

Glue tests were carried out on behalf of the Aeronautical Inspection Department, Government of India. These tests are a check on the Ground Engineers who submit glued specimens for test in accordance with the specifications laid down by the British Engineering Standard Association. Failure on the part of a Ground Engineer to provide joints up to the required standard may result in his licence being endorsed by the competent authority.

Minor Forest Products Section.

The main items of work undertaken during the year under review may be summarised as follows:—

(1) *Portable Charcoal Kilns.*

In last year's report there was a short account of the experimental work carried out with the two French portable charcoal kilns, the "Trihan" and the "La Bastia." It was also stated that, as the result of experience gained with these two kilns, designs for a new kiln had been prepared at the Forest Research Institute and that, in preparing these designs, attention had been paid to the limitation of the size and weight of the component parts, so that they would be readily portable by coolies over long distances.

An experimental kiln of this design was constructed during the year in the Forest Research Institute workshops, and this new kiln has been named the "F. R. I. portable charcoal kiln."

Before passing on to a short description of the work done with this kiln it might not be out of place to reiterate the objects in view in undertaking so much research with these semi-portable metal kilns. The advantages of metal kilns over ordinary country kilns are briefly as follows:—

(*a*) No water is required for their operation.

(*b*) Simplicity of operation.

(*c*) Increased yield and production of better quality charcoal.

(*d*) Elimination of fire danger.

(*e*) The possibility of producing charcoal in rainy weather.

All the above points have been tested and proved with the French metal kilns at the Forest Research Institute. The chief drawback was the high initial cost, and it was to get over this difficulty that the F. R. I. kiln was designed, and it is hoped that it will be possible to put this kiln on the market at a very much cheaper price than that of the French kilns.

Preliminary trials of this kiln were carried out at the Institute with material consisting of saw mill waste and billets of mango (*Mangifera indica*) and other species which had been felled on the estate. As the result of the experience gained, a few minor alterations were made to the kiln which was again tested with satisfactory results.

As the preliminary trials had been successful, it was decided to test the kiln under forest conditions and, thanks to the assistance received from the Divisional Forest Officer, Dehra Dun Division, arrangements were made for these tests to be carried out in a coupe in this Division. The "Trihan," the better of the two French kilns, was also sent out in order that the two kilns might be compared.

They were despatched as far as possible by lorry and were then carried in country carts along a cart track right into the coupe in which they were to be used. During transport it was found that the "F. R. I." kiln occupied much less space than the "Trihan," while it was also easier to handle, as its component parts are smaller and lighter.

The material available for carbonisation in the coupe consisted of the branch wood of *sal* (*Shorea robusta*) trees which had been felled for timber. The moisture content was high, as the trees had only been felled a short time previously. The material was not, therefore, ideal as, not only was it wet, but *sal* is a thick barked species and does not, therefore, take fire very readily.

Twelve kiln charges were burnt in each of the kilns and the results were most satisfactory, the outturn of charcoal from the "F. R. I." kiln comparing very favourably with that from the "Trihan." The outturn from each kiln has been calculated on an oven-dry basis, so the results are strictly comparable. The "F. R. I." kiln gave an average of 34·1 per cent as compared with 33·3 per cent for the "Trihan."

Every endeavour was made to obtain the services of professional charcoal burners to manufacture charcoal in ordinary "country" kilns in order to compare their results with those of the portable kilns, but this unfortunately could not be arranged.

On return from the forest, the "F. R. I." kiln was inspected to see whether it had suffered any damage during the course of handling or in operation. The only defect noticeable was a slight tendency to buckle at the base of one or two of the lower panels, and a 1½" angle iron is now

being fitted as a "stiffener" at the base instead of the 1″ angle iron originally fitted. It is thought that this alteration will overcome this defect. Except for this minor defect, the kiln was in perfect order.

No estimate can yet be formed of the probable life of the "F. R. I." kiln as it has been in use for such a short time. It has been decided, nevertheless, to prepare scale drawings of the kiln and to call for quotations from reliable firms for manufacturing this type of kiln. The materials used in its construction are all of standard sizes available in the Indian market and there should be no difficulty on this score, and it is hoped that it will prove possible to manufacture the kiln a good deal cheaper than the French kilns.

When estimates have been received, the kiln will be brought to the notice of contractors and other persons interested in the hope that it will fill a long felt want. A full note on the kiln will also be made available.

(2) *Charcoal Briquetting.*

The hydraulic laboratory briquetting press was installed in the new Minor Forest Products Laboratory at the beginning of the year and a start was made with this important investigation.

The possibility of using *Bauhinia retusa* gum in combination with other binders of a starchy nature was investigated. Preliminary experiments were directed towards ascertaining the percentage of the various binders required to give satisfactory results, the best method of preparing the mixture for the press, the correct proportion of water to be used, and the effect of the fineness of grinding the charcoal on the subsequent strength of the briquettes.

The briquettes made in each of the experiments were allowed to dry and were then sent to the Timber Testing Section where they were subjected to compression tests. The figures so obtained gave a valuable indication of the comparative strengths of the briquettes made in each experiment and served as a guide for future work.

These figures conclusively proved that the strongest briquettes were produced when the "mix" was first ground in the kollergang of the Paper Pulp Section. This operation not only mixes the charcoal and binders very thoroughly, but also reduces the size of the particles of charcoal and subjects the whole of the mix to a preliminary packing.

The small power driven roller briquetting press, producing ovoid briquettes, was not erected till towards the end of the year, but it was immediately taken into use as the experimental work carried out with the laboratory press had shown that there was every chance of producing satisfactory briquettes on this machine.

All the various mixtures used in the roller press were subjected to a preliminary mixing and grinding in the kollergang, but the work was

slow as the machine only accommodates about 10 lbs. at a time. Financial stringency precluded the purchase of a larger machine to enable the investigation to be pushed forward more rapidly. Sufficient progress was, however, made to indicate that satisfactory briquettes can be made when using 5 per cent. of *Bauhinia retusa* gum and 4 per cent. to 7 per cent. of starchy binders such as powdered rice, powdered *ragi* or maize meal. Such briquettes, when dry, are quite strong and can be dropped from a considerable height on to a cement floor without breaking. Burning tests show that the briquettes are fairly easy to light, though they do not take fire so readily as ordinary charcoal. They do not burn as rapidly as charcoal, but give a good sustained heat and burn away to ash without any tendency to go out. They are slightly lower in calorific value than the charcoal from which they are made and also produce slightly more ash, but this is to be expected from the nature of the binders employed. They also smoke slightly when first lighted, but the smoke does not last long and is not considered a serious defect.

Very much more work remains to be done, but these preliminary experiments are very encouraging and indicate that it should prove possible to manufacture satisfactory charcoal briquettes with cheap binders of this type.

(3) *Determination of the calorific values of the more important fuel woods of India.*

The Upper Grade Assistant, who had been engaged in this work under the supervision of the Biochemist, finished his determinations in December 1931. 152 species were dealt with and separate determinations were made for the sapwood and heartwood of each species. The results of this investigation will shortly be published as a Bulletin.

(4) *Match splints and box veneers.*

The match veneering and splint chopping machines were not installed in the new building until towards the end of the year and no species were tested as to their suitability for match manufacture.

(5) *Production from chir tar of a material suitable for road painting purposes.*

Reference was made in last year's report to the trials made with "Pintar," the name given to the composition evolved from *chir* (*Pinus longifolia*) tar by the Biochemist for use as a road surfacing material and to the fact that an improved composition had been evolved and the cost of its manufacture reduced.

Supplies of "Pintar" were prepared according to the new formula and were tested on a portion of road. The results were, however, un-

satisfactory, and the "Pintar" was said to lack penetration and to be too brittle to stand up well under traffic. It was also found that it was impossible to deliver it at a price which would allow it to compete with proprietary road compositions and it has been decided, therefore, not to pursue this enquiry any further.

(6) *Rendering bamboo lance staves immune from attack by the shot borer beetle.*

The experiments to determine the susceptibility to attack by the shot borer beetle (*Dinoderus* spp.) of bamboos felled at different periods of the year were brought to a close. Each bamboo which had been exposed to attack was carefully examined and the severity of attack recorded.

From each lot of bamboos felled, two bamboos were selected, and an analysis was made of their moisture, sugar and starch contents. These results were then graphed together with the incidence of attack on similar bamboos in each lot. The graphs were then carefully examined to ascertain whether moisture content and starch and sugar ratios had any influence on the liability to attack. No reliable deductions could however be made at first as there were breaks in the graph at times when representative bamboos had not been analysed owing to the intervention of holidays or for other reasons. It was thought better, therefore, to attempt to supply the missing figures by interpolation of the results obtained by analysing fresh bamboos felled at periods for which figures are wanting.

Arrangements were therefore made to fell the necessary bamboos and to have them analysed, but this work was not completed before the end of the year.

As soon as the analyses have been completed a careful study will be made of the data collected. Attempts were also made to ascertain the effect of varying degrees of severity of attack on the strength of the bamboos, and material for this purpose was handed over to the Timber Testing Section, but the results are not yet available.

(7) *Study of crude drugs.*

During the previous year arrangements were made for supplies of 4 crude drugs for analysis and study by the Biochemist. A preliminary report on one of these, namely *Actinodaphne hookeri*, was received from the Biochemist during the year under review. Analysis showed that the bark contains an alkaloid to the extent of 0·9 per cent, while the leaves contain the same alkaloid, but in a much smaller proportion (0·14 per cent). The alkaloid isolated differed from laurotetanine, which is known to occur in many of the *Lauraceae*, and a small quantity was sent to the

School of Tropical Medicine for determination of its physiological properties. Arrangements were also made for further supplies of the bark in order that the alkaloid may be further studied.

During the year supplies of the following crude drugs were made to the Biochemist for analysis and study :—

(*a*) *Artemisia maritima* from the Punjab and Kashmir for further study of the seasonal variation in santonin content.

(*b*) *Inula roylei.*

(*c*) *Inula racemosa.*

(*d*) *Jurinea macrocephala.*

(*e*) *Iris* spp.

A report was received on (*b*) and (*c*) and the analyses of the roots showed that both species contain an oily crystalline product consisting mainly of alantolactone and a small quantity of alantol. The water extract on removal of colouring matter gave about 10 per cent of inulin in both cases. The alcohol extract, on removal of the colouring matter, gums and resins, gave a small quantity of an alkaloid (0·01 per cent). The quantity isolated was too small for identification and it is thought that the medicinal properties and bitter taste attributed to these species may be due to this alkaloid. *Inula racemosa* appears to be decidedly superior to the *Inula helenium* of commerce in its essential oil content.

(8) *Cutch and katha.*

The periodical analyses which were being carried out to determine the effect of storage on the chemical composition of the sapwood and heartwood of *Acacia catechu* were brought to a close, as it was found that no results of any value were being obtained.

(9) *Finding a market for the third quality turpentine produced by the Bareilly Rosin and Turpentine Factory.*

A further study was made by the Biochemist of the products obtained by " cracking " III quality turpentine. The " cracked " oil was easily separated into four main fractions, which could be further sub-divided into fractions distilling within a range of 5°C. The physical constants suggest that the lower fractions (up to 125°C) consist mainly of the open chain unsaturated carbons ; the middle fraction (150°-180°C) of terpenes, and the higher fraction (252°-267°C) of undecomposed longifolene with some other isomeric sesquiterpene produced as the result of high temperatures and pressures.

The main conclusions arrived at as the results of the experiments are that the so-called third quality turpentine when cracked at a temperature of 412°C and at a pressure of 140 lbs. per sq. inch yields :—

1. 20 per cent of 1st quality turpentine (top cut).

2. 6·6 per cent light oils (up to 125°C).
3. 7·9 „ „ middle oils (125°-155°C).
4. 10·2 „ „ terpene fractions (155°-180°C).
5. 12·2 „ „ mixed oils (180°-245°C).
6. 29·2 „ „ undecomposed oils (250°-267°C).
7. 13·9 „ „ residue, gases and loss.

(10) *Minor Forest Products Museum.*

The exhibits in 4 show cases were completely reorganized on the lines referred to in last year's report and the results are very satisfactory. Progress is necessarily slow but the work is fully justified by the results obtained.

(11) *Minor Forest Products Garden.*

Clearing of the land for this garden was completed during the year and some exhibits were added.

The *Artemisia maritima* seedlings, which were planted out the previous year, suffered badly from attack by white ants. This attack was stopped by removing the sticks, which had been used to support the plants, but not before a great many had been killed. It was noticed that the plants did not appear to be healthy at the end of the rains, but, as the weather grew warmer the growth improved and the plants now appear to be quite healthy.

A sample collected in August showed a santonin content of 0·75 per cent on analysis. This compares unfavourably with a sample collected at the same time in Kurrum, which gave a santonin content of 1·3 per cent. The seeds from which the plants were grown were obtained from Kurrum and it would appear, therefore, that the santonin content of *Artemisia maritima* is reduced when it is grown outside its natural habitat, but it is possible that the santonin content will improve when the plants become acclimatised.

PAPER PULP SECTION.

Experimental Factory.

Activities in the experimental factory consisted of (1) investigations on special problems and (2) manufacture of pulp and paper. Due to financial stringency activities were curtailed towards the close of the year under report, with a view to saving money on the consumption of coal, raw materials, and chemicals.

(1) Investigations on special problems.

(a) *Mechanical treatment of bamboo.*

The Norris and Christy disintegrator, obtained from the Imperial Works Department, Delhi, was erected in June 1931. Experiments on the machine were carried out throughout the year. It was found necessary to effect, from time to time, minor modifications in the machine. Experiments are still in progress to obtain the desired degree of disintegration of bamboo with a minimum loss of raw material. An economic and satisfactory method of mechanical treatment of bamboo, prior to digestion, will, it is hoped, help in the reduction of the cost of production of bamboo pulp.

(*b*) *Preparation of bamboo pulp suitable for the artificial silk industry.*

Experiments were carried out on the preparation of such pulp from *Melocanna bambusoides* (*muli*) bamboo, as Messrs. The British Development Trust Ltd., London, were interested in this species of bamboo. A sample of the pulp made was supplied to the firm in January 1932. The firm forwarded the sample to Messrs. Courtaulds Ltd. for a test on its suitability for artificial silk manufacture. The report on the sample of pulp is awaited. The Indian Merchants' Chamber, Bombay, are also interested in the preparation of bamboo pulp, suitable for artificial silk manufacture. Experiments are, therefore, in progress to develop a method for the manufacture of such pulp on a factory scale ; the previous samples having been prepared on a laboratory scale only.

(c) *Preparation of kraft and wrapping papers.*

A few more runs of kraft paper from *Melocanna bambusoides* (*muli*) bamboo were made, with and without the addition of stayco gum—a corn product manufactured by Messrs. A. E. Stayley Manufacturing Co., Ltd. As the addition of the gum was not found to impart to paper any appreciable increase in strength, further trials of the material were given up.

As the consumption of kraft and wrapping paper in the country is increasing, it is proposed to take up experiments on the manufacture of these papers from bamboo and grasses, as soon as the rod mill, which has recently been received, is in operation.

(d) *Comparison of papers made from sabai grass (Ischoemum angustifolium) and Dendrocalamus strictus bamboo.*

At the request of the Tariff Board, experiments were undertaken to compare the relative strengths of papers made from these two raw materials. The results of the experiments did not lend support to the view, commonly held, that *sabai* grass paper is stronger than bamboo

paper. When made under exactly comparable conditions bamboo paper was found actually to be stronger than *sabai* grass paper.

(2) Manufacture of pulp and paper.

(*a*) About a ton of *Melocanna bambusoides* (*muli*) bamboo pulp was supplied to Messrs. John. M. Watson & Co., Glasgow, for conversion into paper on a large scale. Their report on the paper making qualities of the pulp is awaited.

(*b*) Over 3 tons of bamboo writing, printing and packing papers, mounting boards, and cardboards were supplied during the year to the various offices of the Forest Research Institute and College.

(*c*) Nearly one ton of bamboo printing paper was also supplied to the Government of India Press, Calcutta, for the printing of 18 publications of the Forest Research Institute and College.

Laboratory.

The dismantling of the old laboratory and the equipping of the new laboratory was completed in June 1931.

(1) The following routine analytical work in connection with factory operations was carried out :—

(*a*) Moisture determinations and analyses of chemicals used in the digestion of raw materials, in bleaching of pulp and in making paper.

(*b*) Analyses of the main supply of the boiler feedwater and of chemicals used for softening this water which is extremely hard.

(2) Special investigations.

(*a*) Experiments on *Saccharum spontaneum* (*kans*) grass and *Desmostachya cynosuroides* (*dab*) grass were continued from last year. It was found that in addition to straw-boards and wrapping papers, the grasses could be utilised for the manufacture of cheap *badami* papers. Semi-commercial tests on the grasses, to confirm laboratory results, will be taken up when the rod mill is in operation.

(*b*) The experiments on flax tow were also continued from last year. A method was worked out for the production of bleached pulp from this material, suitable for use in the manufacture of high class papers. Messrs. The Upper India Couper Paper Mills, Lucknow, were good enough to give permission for large scale trials on the material to be carried out in their mills. As, however, sufficient quantities of the raw material could not be procured at the time the large scale tests had to be put off until supplies of the material were available from the next linseed crop.

(*c*) Determinations of the chemical constituents of *Ochlandra brandisii* (*eta*) bamboo fibre were carried out in full detail, according to the standard methods of analyses.

(*d*) Experiments on bagasse (crushed sugar cane) were undertaken at the request of the Officer on Special Duty, Hydro Electric Circle, Roorkee, with a view to utilising surplus power from the Ganges Canal Hydro-Electric Scheme. It was found that the material could be used for the manufacture of boards and ordinary wrapping papers. Semi-commercial tests, to confirm laboratory results, will be carried out when the rod mill is in operation.

(*e*) Tests were carried out on sunn-hemp stalks, sent by the Principal, Harcourt Butler Technological Institute, Cawnpore. The material was found suitable for the manufacture of straw-boards.

(*f*) Experiments on Nilgiri blue gum (*Eucalyptus globulus*) are in progress with a view to preparing from it a pulp suitable for the manufacture of cheap grades of paper.

(*g*) A bamboo (probably *Bambusa arundinacea*) from the Andhra Paper Mills Co., Ltd., Rajahmundry, was tested to ascertain the cause of excessive consumption of bleach in the mills. The bamboo chips supplied were found to be fungus attacked. A fresh consignment of bamboo stems has been obtained to continue the investigation.

Supply of technical information and advice.

(*a*) At the request of Messrs. The Upper India Couper Paper Mills, Mr. Bhargava went to Lucknow to discuss with the management details of a project for the improvement and expansion of their mill.

(*b*) Representatives of Messrs. The Punjab Straw Board Ltd. visited Dehra Dun to discuss with the Officer in Charge a scheme for the establishment of a straw-board mill near Lahore. Detailed information regarding processes, machinery, etc., was supplied to the representatives.

(*c*) During the year under report correspondence was carried on with private individuals, commercial firms and Government Forest and Industries Departments in connection with 21 enquiries referred to the Section for advice.

Lectures.

The usual course of lectures and practical demonstrations were given by the Officer in Charge to students of the Senior Indian Forest Service Class.

Tariff Board Inquiry.

The Indian Tariff Board visited the Section and examined Mr. Bhargava on the 28th July 1931, in connection with their enquiry on the grant of protection to the Paper and Paper Pulp Industries.

Development of Bamboo Pulp Industry.

It is understood that Messrs. The British Development Trust Ltd. propose to make a start very soon with the Lemro Burma Scheme, and that another big pulp mill may be put up in the Tavoy area before long. Messrs. The Titagarh Paper Mills, the India Paper Pulp Co. and the Bengal Paper Mills Co. are planning to increase the pulp capacity of their mills and to use bamboo for the purpose. There are thus signs of increasing development in the bamboo pulp and paper industry of the country. The imposition of the new customs duty of Rs. 45 per ton on imported wood pulp will no doubt tend to help this development.

MECHANICAL SUB-SECTION.

This sub-section remained busy during the year on repairs and maintenance of plant, and on the making and repairing of tools and implements.

The total number of jobs completed during the year was about 450, which does not include a large number of a minor nature which were not recorded.

In addition to the main research equipment all the electrical installations, railway tracks and trucks, boilers and fittings, fire extinguishing appliances, and lorries were maintained in good order throughout the year.

CHAPTER V.

ENTOMOLOGY BRANCH.

Insects attacking Shorea robusta.

No field work on *sal* insects was done by the Institute staff during the year and no report of unusual damage by defoliators or borers was received.

Hoplocerambyx spinicornis Newm.—Control measures against the *sal* borer were continued by the divisional staff in the affected divisions in the Central Provinces. A summary of six years' work, based on the records maintained by those divisions, is given below :—

Division.	Year.	Borer attacked trees felled and burnt.	Trap trees felled.	Beetles caught.
South Mandla	1926-27	149,307	200	..
	1927-28	170,057	17,830	540,017
	1928-29	35,455	15,058	470,222
	1929-30	1,570	..	..
	1930-31	61	1,140	6,491
	1931-32	..	1,475	..
Balaghat	1926-27	5,000	1,510	4,971
	1927-28	..	18,613	408,467
	1928-29	31,000	..	654,639
	1929-30	..	8,355	108,022
	1930-31	..	1,417	16,062
	1931-32	..	212	1,122
Bilaspur	1926-27	3,010	..	..
	1927-28	1,708	3,011	315,941
	1928-29	184	2,539	122,333
	1929-30	..	468	7,079
	1930-31	..	172	4,042
	1931-32	..	..	..

Secondary borers.—Reports were received from Tikri forests, Gonda Division, United Provinces, that *sal* was dying in small groups. Examination of wood sent showed attack only by a secondary borer, *Chrysobothris* sp. (Buprestidae), to which the death of the tree could not be ascribed; the roots were examined by the Mycologist and showed symptoms characteristic of *Polyporus shoreae*. In Pawalgarh and Sandni blocks of the Dechauri range, Ramnagar Division, United Provinces, *sal* trees were reported dying in all places and a moth *Gerontha captiosella* Wlk., larvae of which bore into fresh dead wood, was found to be present.

Insect attacking Tectona grandis.

Dihammus cervinus Hope.—Observations have been continued in the plots (with over 6,000 trees) laid out in a two-year-old plantation to measure the effect of weeding and not weeding during the monsoon season.

The biology of the borer studied in the outdoor cage (Insectary), Dehra Dun, shows that it has an annual life cycle. Plants inoculated between mid-July and mid-August 1930 yielded beetles in August 1931.

Hyblaea puera Cram.—Preliminary experiments indicated that a preference for *Vitex negundo* is shown by the moth when ovipositing.

In the Insectary outdoor cage containing teak, *Vitex negundo*, *Callicarpa arborea* and *Premna latifolia*, moths were liberated and it was found that 27 eggs had been laid on *Vitex negundo* and 2 on *Callicarpa arborea* while *Premna latifolia* and *Tectona grandis* had remained free due to the hard leaves being unacceptable to the moth for oviposition. In the field, eggs and larvae were detected on *Premna latifolia* only towards the end of March. In April they were found on *Vitex* and on the new flush only of young teak plants in the Silviculturist's demonstration area but none found on large teak trees that had only old leaves on them.

Hapalia machaeralis Wlk.—In the field larvae were found hibernating, during March, amongst dry fallen leaves underneath the defoliated teak trees. Larvae collected during November passed 5 months in hibernation and, during March, the proportion of different stages under laboratory condition were found as below :—

	Larvae per cent.	Pupae per cent.	Adults per cent.
Beginning of March	100	..	..
Mid March	80	20	..
End March	28	54	18

Eupterote sp.—Larvae of this teak defoliator were received from Betul Division, Central Provinces, in August. They continued feeding on hard and tough leaves up till January when they went into the soil for pupation.

Parasites and predators.—The following have been discovered and studied :—1. *Sturmia* sp.—This tachinid fly parasitises the last instar larva of *Hyblaea puera* Cram, laying 1-3 eggs in the body of its host. 2. *Calleida splendidula* F.—The larva and beetle of this carabid were fed on *Hyblaea puera* larvae. The beetle was successfully reared from the larva in this way. It was found also to feed on several other species of lepidopterous larvae. 3. *Hierodula westwoodi* Kby.—This mantis preys in the nymphal and adult forms on *puera* and *machaeralis* larvae. 4 *Syrphidae.*—The larva of a species of this fly has been found devouring the full grown larva of *Hapalia machaeralis* Wlk. It hibernates as a puparium for about 3 months (December to February).

Borers of Indian Timbers.

Borers in timber yards.—Timber yards of Calcutta were visited in September 1931 when timbers from the Andamans and from Bengal and Assam were examined. The existence of attack by the following shot hole and pin hole borers was noticed :—(1) *Xylothrips flavipes* Ill. (2) *Heterobostrychus aequalis* Waterh. (3) *Minthea rugicollis* Walk. and (4) *Lyctus spinifrons* Lesne. The absence of *Lyctus africanus* Lesne has yet to be confirmed and this point will be made clear when the emergence records of the breeding material caged in Insectary are worked out.

United Provinces Semul borers.—Treated and untreated *semul* logs were subjected to the attacks of a large number of *semul* borers which were released alive inside a wire gauze outdoor cage. Logs with bark were swabbed over with creosote, crude petroleum, Burma Shell Furnace oil and their mixtures but they did not prove deterrent to oviposition or boring by the *semul* borers. Both the treated and untreated logs were found attacked and the borers, after completing their life cycle within the logs, are now emerging.

Borers attacking bamboos.—Investigations on the correlation of time of felling and subsequent insect attack are still in progress. Bamboos are being tested by the Timber Testing Section to determine the effect of insect attack on strength.

Insects attacking Pinus longifolia.

Material collected in the field (Hoshiarpur and Rawalpindi East Divisions, Punjab) during the previous year was utilised in studying, under laboratory conditions, the biology of the *chir* pine bagworm, *Clania crameri* Westw. (Psychidae) and its parasites.

Parasites.—Two species of Ichneumonid, a Tachinid and a Chalcid, emerged during March, April and May from bags containing parasitised larvae. Their identification by a specialist is awaited. Moths emerged during the latter half of May and first half of June.

No field work for devising and testing the remedial measures was undertaken as the local officer thought that control measures would involve too great expenditure.

Insects attacking Dalbergia sissoo.

Plecoptera reflexa Guen.—The life history study of the moth was continued in the Insectary under indoor and outdoor conditions. Leaves of *shisham* trees in the cages were heavily infested with 2 or 3 species of Coccidae, Membracidæ and Aleurodidæ.

Insects attacking Gmelina arborea.

Calopepla leayana Latr.—Some beetles were released in the outdoor cage to study hibernation of the defoliator. Though new leaves were put out in March, the insects have not yet revived their activities.

The biological study of a species of *Chalcis* parasitic on *Calopepla leayana* was made. The female oviposits in the last stage larva of this beetle. The parasitised larva then pupates and the chalcid emerges after cutting a circular hole on the dorsal surface of the pupa. The life cycle of the *Chalcis* occupies about a fortnight. Two generations were carried through between September and October. The adult chalcids began to hibernate towards the end of October. They lived all through the winter to die in March.

Tingidae.—A heavy *Tingid* attack was observed on *gamari* (*Gmelina arborea*) resulting in the gradual withering of the leaves which eventually dropped down. Dusting with Cyanogas powder proved successful as a control measure.

The Mulberry defoliator.

Glyphodes pyloalis Wlk.—As the male and female moths emerged from the pupae of the hibernating larvae, at different times, there was no egg laying. Field collection and life-history studies of the pest continued. It hibernates as a larva. Thread worms were responsible for high mortality amongst the larvae during the year. Each larva may contain one or two worms within its body cavity. Moths from pupae of the hibernating larvae began to emerge from the middle of March.

Deodar nursery insects.

In May 1931 it was reported that deodar nurseries at Mundali, Chakrata, United Provinces, were very severely attacked by insects and that 200,000 plants, 2-3 years old, were killed within a month and a half out of a stock of about 500,000 plants in 1930. Another report was received in 1931 from Seraj Division, Punjab, stating that deodar seeds sown in nurseries had been damaged by insects.

Investigation of the mortality of deodar seedlings carried out at Mundali in October 1931, showed that the dying back of the roots was often due to injuries at the time of transplanting. In a few cases fresh damage by cockchafer grubs was observed but in all cases only the living green bark near the upper part of the root was gnawed ; no insect damage was observed on healthy plants. Cockchafer larvae were recovered but in negligible numbers.

Dying off to the extent of 50 or 60 per cent has been reported to occur between the months of March and May. A considerable proportion of this is likely to be due to other causes than insect damage. The actual extent of insect damage is being investigated.

Bamboo defoliator.

Pyrausta coclesalis Wlk.—Moths from pupae of the hibernating larvae of 1930 emerged from last week of May to 16th July. As the emergences of male and female occurred on different dates no oviposition was possible.

In the field, larvae made their appearance on the 18th July. Since then three generations have been carried out, the larva of the last being still in hibernation. Life of the adult male moth was found to be 6-7 days and that of female 10-16 days, when fed on honey. The total number of eggs laid by a single female was 687, with an average incubation period of 3-5 days during summer and 5 days during winter. The larval and pupal periods were found to vary greatly in different generations. Many species of parasites were also bred out.

Termites.

Experimental studies were made with termites in relation to durability of timbers. The termites used for graveyard tests were identified as *Odontotermes bangalorensis* Holmg. With regard to the seasonal incidence of soil termites, they were most abundant and active during the summer and rains but in winter their activity was somewhat decreased. The intensity of attack was much greater on imbedded *semul* stakes than on wood merely placed on the surface of the ground. Seventy-five wood species were tested and found damaged by termites either moderately or to a small extent. It was noticed that amongst the treated baits, creosoted ones remained unattacked, whereas cubes treated with 2 per cent. Sodium fluoride, Celcure and Earth oil were slightly attacked.

The Spike Disease of Sandal.

Analyses and Taxonomy of Sandal Insects.—The field surveys referred to in the last report were concluded in December 1931, the resultant

taxonomic and analytical work being undertaken at Dehra Dun by Mr. C. Dover, with the assistance of the Section of Systematic Entomology. The primary object of this survey was the accumulation of data which could be applied to the selection of possible vectors for experimental investigation. From a more general point of view the survey is of interest in that it represents the first extended study of the fauna of an Indian forest tree and furnishes material for an important contribution of economic, biologic and taxonomic value, to the entomology of South India. A very large number of both common and rare species was obtained, a valuable addition to the collections of the Branch.

As a sound taxonomic foundation was obviously a necessary preliminary to a productive study of this material, a representative selection of all the groups contained in it, except certain families which are being studied at Dehra Dun, was sent to some thirty specialists in India, Europe and America for determination and report. This procedure will result in a series of taxonomic papers to which the available bionomic and other data will be added. The series will be concluded with an analytical and comparative summary, written with particular reference to the spike problem as it then stands. Several papers have already been received and it is hoped to complete the project in 1932-33.

Meanwhile more immediate needs have not been ignored. The general results of the survey and its bearing on the spike-disease problem forms the subject of a paper by Mr. Dover (*Indian Forest Records*). This has since been supplemented with a note on probable vectors, which has reduced the number of species (see last Annual Report) thought to be deserving of immediate consideration. On the basis of our present information it would appear that spike is probably conveyed by a specific vector, and the available data indicates *Moonia variabilis* Dist. (Jassidae) as a likely species, but experiments with *Acropona walkeri* Kirk. and other Jassinae will be made. Aphididae are not represented in the quantitative collections, but attention has been drawn to their possible importance.

Bionomics of Sandal Insects.—Mr. N. C. Chatterjee commenced a study of the fauna of sandal in healthy and spiked areas in combination with each of the following hosts: *Albizzia amara, Canthium didymum, Erythroxylon monogynum, Lantana camara, Pterolobium indicum, Scutia indica* and *Zizyphus oenoplia*. More than 4,000 unit collections have so far been obtained, which are now being analysed and compared. It is hoped that the resultant data will provide information on (1) the food plants of sandal insects, which will assist in the collection of insects for transmission experiments and in the study of control measures if a vector of spike-disease is found; (2) differences in the fauna of the various combination and of resistant and susceptible hosts. The life-history of

Acropona walkeri Kirk., *Ledra mutica* Fabr. and *Eurybrachys tomentosa* Fabr. has been studied.

Transmission Experiments.—Attempts to transmit spike-disease to healthy sandal plants by specimens of *Moonia variabilis* Dist. and *Petalocephala uniformis* Dist. (Jassidae) and *Sarima* sp. (Fulgoridae) have not so far been successful. Thirty-six experiments, accompanied by controls, were conducted and are still under observation.

In thirty-five experiments, accompanied by controls, specimens of three species of Curculionidae (*Sympiezomias cretaceous* Fst., *Dereodus sparsus* Boh. and *Myllocerus* sp.) were fed on a spiked plant and then transferred to healthy sandal plants. In all the experiments an unknown leaf-disease was transmitted to the healthy plants, the controls producing negative results. Further experiments, with more conclusive technique, are now being conducted with reference to the possibility of (1) the infective source being diseased in addition to spike, (2) the leaf-disease being a preliminary symptom of spike-disease, (3) spike being due to a complex virus, of which the leaf-disease is a component that can be isolated and transmitted by these weevils.

Attention is now being concentrated on transmission experiments at Bangalore, where the Indian Institute of Science have provided a special laboratory and insectary in addition to other facilities.

Leaf Crinkle of Zinnia.—Experiments on this virus disease were concluded during the year and a paper on the subject was prepared for publication by Mr. R. N. Mathur. The subject was taken up originally as subsidiary to the sandal-spike problem as an exercise in technique in dealing with virus-conveying insects. In this case the vector belongs to the family Aleyrodidae and the disease is very closely related to leaf-curl of cotton.

General Insectary Work.

During the year under report, 176 consignments of attacked material and insect specimens were received from various forest divisions of India for breeding, identification or report. 192 cages were discontinued and 448 are still current and under observation. The total number of insects bred was 49,077 and of these about 25,460 were set. Various host plants for experimental work were maintained in the fenced garden and in the outdoor wire gauze cages. A new outdoor wire gauze cage and a potting shed, 35 ft.×20 ft., were added during the year. The growth of sandal seedlings was very slow. About 55 seedlings were transplanted with *Cajanus indica* as host in large pots.

Systematic Entomology.

The identified insect collection has been increased during the year by about 500 species, most of them Indian. Many of them are new to science. The majority of the insects reared in the insectary were identified at Dehra Dun.

The following specialists, in addition to those mentioned in last year's report, have given us valuable assistance: Messrs. V. Lallemand; Rudolf Heberdey; F. W. Edwards; L. Chopard; T. E. Snyder; Nathan Banks; W. D. Funkhouser; Louis Fage; R. Malaise; T. V. Ramakrishna Ayyar; D. Mukerji; Karam Singh; H. S. Pruthi.

The Systematic Entomologist continued the study of coleopterous larvae and of Cerambycidae producing two papers dealing with these subjects.

The staff have been mainly engaged in the disposal of several thousands of insects collected during the extensive Sandal Insect Survey in South India. A few taxonomic reports on this material have been received from different specialists and are ready for publication. A few papers dealing with new species from the collections of this Institute have already appeared, some in Indian Forest Records and others in foreign journals.

Tours.—By the Forest Entomologist to Bangalore in June; to Calcutta and Ranchi (Bihar and Orissa) in September; to Chakrata Hills, United Provinces, in October. By the Systematic Entomologist to Ranchi, Bihar and Orissa, in February. By Mr. N. C. Chatterjee and party in Bangalore, North Salem and Vellore Divisions, Madras, and Fraserpet, Coorg, throughout the year. By Mr. C. Dover to Bangalore, North Salem and Vellore Divisions, Madras, and Coorg in April 1931. By Mr. B. M. Bhatia to Calcutta in September and to Chakrata Hills, United Provinces, in October. By Mr. S. N. Chatterjee to Haldwani, United Provinces, in April.

Lectures.—The course in Forest Zoology for the two Indian Forest Service classes was conducted by Dr. C. F. C. Beeson (seniors) and Mr. C. Dover (juniors).

Museum of Forest Zoology.—This has been extensively supplemented with diagrams and specimens used for students' demonstration. Specimens of a dugong and its skeleton were also added during the year.

Library.—269 books besides periodicals were added to the Zoological Library during the year.

CHAPTER VI.

CHEMISTRY BRANCH.

The following programme of work was undertaken during the year under report:—

1. General study of the chemistry and commercial uses of the minor forest products—

(*a*) Drugs:—

(i) Indian *Artemisias.*

(ii) Indian *Ephedras.*

(iii) *Actinodaphne hookeri.*

(iv) *Adhatoda vasica,* Nees.

(*b*) Oils and Fats:—

(i) Fat from the seeds of *Vateria indica* Linn.

(ii) Fat and oil from the seeds of *Actinodaphne hookeri.*

(*c*) Essential oil:—

(i) *Inula racemosa.*

(ii) *Inula royleï.*

(*d*) Colouring matter:—

Garcinia morella.

2. Study of the Forest Soils.

3. Miscellaneous enquiries.

Minor Forest Products.

(*a*) *Drugs.*

Indian Artemisias.—It was reported last year that the Kurram Valley (North-West Frontier Province) *Artemisias* were being investigated with a view to finding additional or replaceable sources of this valuable anthelmintic. Data that has so far been collected on the subject is detailed below. There are five species of *Artemisias* found in the Upper Kurram, namely, *A. scoparis,* Wallst; *A. tournefortiana,* Reich; *A. absinthium,* L.; *A paraviflora,* Roxb. and *A. maritima,* Linn. Of these *A. maritima* is the only one that contains santonin. Its characters are as follows:—root stock woody, branched, stems upto $3\frac{1}{2}'$

high, woody or wiry, erect or ascending, much branched from base, leaves $\frac{1}{2}$" to $2\frac{1}{2}$", pinnatisect, with linear sprady segments, hairy. Flowerheads numerous with usually 3 rarely 4 flowers, ellipsoid. It has a pleasant sweet odour. It grows in Mallikhel, Taida (known as the Trans-Kurram area) and in Dandar Road, Laila Danda, Nastikot, Shinghak, Kharlachi, Burki, Bughdi and Lalmi (known as the Cis-Kurram area).

It was also reported last year that *A. maritima* from many of the localities named above had been examined and some of the localities yielded varities rich in santonin whereas the others were very poor, even though these places are only a few miles apart. There do not appear to be any constant characters by which a botanist could differentiate the santonin yielding forms of *A. maritima* from those which contain little or no santonin. The Trans-Kurram *A. maritima* is practically useless. Out of about 40 samples collected from this area only 4 have yielded any santonin and, even in these, the percentage was low. The same is true of Dandar Road and Laila Danda in the Cis-Kurram while the rest of the localities in this area give *A. maritima* rich in santonin. This led to the search for some typical characters by which the different forms of *A. maritima* could be distinguished. Careful investigation has revealed one prominent character that may help to identify the form of *A. maritima* rich in santonin from those that are poor. And it is the colour of the stem. In early stages the stem is in some cases grey, while in others deep red. Towards the end of June, however, the red stem begins to turn brown and at maturity stems in all cases turn brown when the differentiation of red and brown is lost. The plants that have reddish stem, in the early stages, give santonin while those with greyish stem, do not. The former has, therefore, been considered as a distinct form and has been designated as *A. maritima* form *rubricaule*. Trans-Kurram *A. maritima*, with very rare exceptions, has grey stems in early stages whereas the Cis-Kurram has the red stem form with the exception of Dandar Road and Laila Danda which have both the forms.

A. maritima form *rubricaule* is distinct from the other two varieties of *A. maritima* found in the Upper Kurram, namely, *A. maritima* L. Var Hk. f. et Th—and *A. maritima* L. Var *Thomsoniana*. The first of these differs from the santonin yielding varieties in having no smell at all and is very sticky on account of the large amount of resin that it secretes while the other, though possessing a strong odour, has a dense covering of whitish hair.

The time of the year when *Artemisias* should be collected for the extraction of santonin has also been studied and it is found that, in the case of the Kurram Valley August and September appear to be the best months when the flowerheads are fully formed and begin to show signs

of opening. The seasonal variation of santonin (in the entire plant, excluding thick stems) is given in the table below :—

Month.	Santonin content (Average of weekly collections).
	Per cent.
April	0·5
May	1·0
June	1·2
July	1·0
August	1·4
September	1·6
October	1·0
November	0·7
December	0·6

Up to about the second week in June the plant consists mainly of leaves and after this period the flowerheads start making their appearance and by September when the flowerheads have fully grown the leaves start falling off. It has been observed that santonin is at first confined, almost wholly, to the leaves and as soon as the flowerheads have made their appearance it begins to concentrate there in quantity greater than in the leaves. This is clearly shown in the following table which gives the relative proportion of santonin in leaves and flowerheads :—

Date of collection.	Leaves per cent. santonin.	Flowerheads per cent. santonin.
12th April	0·40	Flowerheads not formed.
19th April	0·48	
27th April	0·43	
8th May	0·85	
18th May	0·95	
30th May	1·11	
11th June	1·21	
30th June	1·05	Flowerheads appear.
9th July	0·49	1·19
19th July	0·30	1·74
4th August	0·34	1·52

Before the drug is stored, it is thoroughly dried by spreading in the strong sun. An interesting observation has been made in this connection and it is that *A. maritima* loses a portion of its santonin when dried in the sun. For these experiments collection was made from a single plant and the total divided in two halves; one half of which was dried in the sun and the other in shade. The following results were obtained:—

Date of collection.	Dried in shade per cent. santonin.	Dried in the sun per cent. santonin.
19th April 1931	0·63	0·57
27th April 1931	0·51	0·50
8th May 1931	1·23	1·00
18th May 1931	1·40	1·10
30th May 1931	1·00	1·30

(NOTE.—The above samples contained about 15 per cent. of moisture but for the sake of comparison are expressed in terms of Zero moisture.)

The effect on the santonin content of *A. maritima*, on long storage, has also been observed and it is that the santonin content is not appreciably affected, provided it has been kept in a cool dry place. The following analyses show this :—

Area of collection.	Date of collection.	Date of analysis.	Santonin content.
			per cent.
Nastikot . . .	19th September 1927	October 1927 . .	1·15
Do. . . .	Do. . .	28th January 1931 .	1·04
Kharlachi . . .	Do. . .	October 1927 .	1·04
Do. . . .	Do. . .	September 1930 .	0·84
Burki	18th October 1930 .	4th March 1931 .	1·58
Do.	Do. . .	21st August 1931 .	1·47

Attempts have also been made to grow *Artemisia* in localities with environments altogether different from those available in the Kurram Valley. For this purpose, a crop was raised in this Institute and another in the Royal Botanic Garden, Sibpur, from the seeds obtained from Kurram. Up to about the middle of July the plants grown in Dehra Dun flourished very well but with the monsoon they began to show unhealthy signs, due to waterlogging, and many of the plants subse-

quently died. A sample collected on the 13th of August gave 0·75 per cent. santonin. The Sibpur crop did not do well at all and died before any sample could be collected for analysis.

The above results are summarised below:—

1. There are several species of *Artemisia* found in the Kurram Agency, of which only *A. maritima*, Linn. form *rubricaule* is useful. This is met with in areas Nastikot, Shinghak, Kharlachi, Burki, Bughdi, Lalmi, Kachkina, Kerakhela. In these localities this form of *A. maritima* grows without appreciable admixture of non-santonin yielding varieties and forms.
2. The maximum amount of santonin in leaves is obtained when rudiments of flowerheads have made their appearance on the plants and a period immediately preceding it namely from about the end of May to about the end of June.
3. Highest percentage of santonin is found in immature flowerheads.
4. The best period for collection of crops is from about the 10th of August to about the 10th of September. The collection of the crop should be completed at least 20 days before the flowerheads show first sign of opening.
5. Sun drying appears to lower the santonin content.
6. Long storage does not seem to lower the santonin content.

The botanical description of *Artemisias* described above is by Mr. R. L. Badhwar, an ex-officer of the Botanical Survey of India.

Indian Ephedras.—It has hitherto been the belief that *Ephedras* of high ephedrine content are found only at high altitudes (5,000 ft. and over) and in dry localities. To test this, some of the seeds of *E. sinica* obtained from China were grown in this Institute by the Forest Botanist. In spite of the heavy rains the plants appear to have done very well and gave the following amount of alkaloids:—

Date of collection.	Moisture in the air-dried sample.	Total alkaloids.	Total alkaloids in the samples grown in China.*
	per cent.	per cent.	
15th September 1931 .	8·5	0·75[1]	1·12
17th November 1931 .	8·5	0·49	Not recorded. The highest alkaloidal content is reached by early October after which there is a rapid fall.

[1] The lower alkaloidal content may be due to the heavy rains in August and September 1931.

* Feng and Read, Chinese Journal of Physiology, 1928, Vol. II, p. 87.

Actinodaphnine.—Reference was made last year to an alkaloid that had been isolated from the leaves of *Actinodaphne hookeri*. Further examination has shown that the bark also possesses an alkaloid which is different from that found in the leaves. The alkaloid in the leaves is present in a very small amount and hence it has not been possible to isolate it in pure condition and in sufficient quantity for purposes of identification. The bark, however, has given about 0·7 per cent. of an alkaloid.

Actinodaphne hookeri.—Vern. *pisi* (Bomb)—belongs to a genus of trees or bushes (N. O. Laurineæ) comprising of about 50 species of which 9 or 10 are Indian, inhabiting the warm, moist forest of the lower hills. It is found common in eastern and western Ghats of S. India, in Kanara and particularly in Mahableshwar. Allied to *Actinodaphne* are the *Litsea* species, the best known of which is *Litsea sebifera*, Vern. *maida lakri* (Hind). It is one of the most popular Indian drugs being used in diarrhœa, dysentry and also as a nervine tonic.

From the bark of *Litsea sebifera* an alkaloid has been isolated which in its characteristics appears to agree with laurotetanine, an alkaloid isolated by N. Greshoff (Ber. 1890, 23, 3537) from some species of *Litsea* in Java and several other plants of the N. O. Laurineæ. A base which seems to be identical with laurotetanine is also found in the varieties of *Tetranthra, Notophoebe, Aperula, Actinodaphne* and *Illegra pulchra.* From the physical and chemical data hitherto obtained actinodaphnine appears to be different from laurotetanine. This is shown in the table given below :—

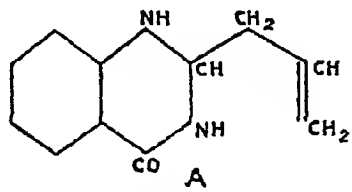
——	Actinodaphnine.	Laurotetanine.
Base—		
Formula	$C_{18}H_{19}NO_4$	$C_{19}H_{21}NO_4$
m.pt.	210°C.	134°C.
Water of crystallisation . . .	*Nil.*	one.
$[\alpha]_{20^\circ}^{D}$ in alcohol	+32·77°	+98·5°
Base, hydrochloride—		
m.pt.	280°-81° C.	46° C.
Water of crystallisation . . .	*Nil.*	six.
mpt. of anhydrous	280°-81° C.	decomp. at 230° C.
$[\alpha]_{20^\circ}^{D}$ in water	+8°·45′	+42°·3′

——	Actinodaphnine.	Laurotetanine.
Base, Sulphate—		
m.pt.	248°-250° C. with decomp.	....
Water of crystallisation . . .	three	five.
Base, picrate—		
m.pt.	220°-222° C. with decomp.	148° C. with decomp.
Water of crystallisation . . .	one	one and a half.
Base acetylated—		
m.pt.	220°-30° C.	154° C.
Colour reactions—		
In conc: H_2SO_4	Pink changing to purple.	Blue changing to violet.
In conc: $H_2SO_4+K_2Cr_2O_7$ . .	Deep blue	Green.

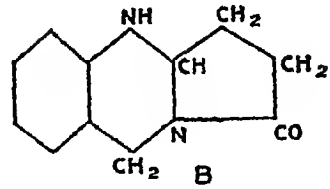
The analytical data, molecular weight, equivalent weight, etc., all tend to indicate for the alkaloid the formula $C_{12}H_{19}NO_4$ and a molecular weight 313. Preliminary examination shows it to contain a hydroxyl group, a methoxyl group and a nitrogen methyl group. Possibilities of a second hydroxyl and methoxyl group have also been explored but with negative results. The alkaloid gives no oxime or a hydrazone and, therefore, the absence of an aldehydic or carbonyl group is strongly suspected. From these it appears that the alkaloid from *Actinodaphne hookeri* is quite different from laurotetanine which contains three methoxyl and one hydroxyl group.

Adhatoda vasica.—Further work on this subject has confirmed our previous conclusions that vasicine has the formula $C_{11}H_{12}N_2O$; that on fusion the alkaloid gives anthranilic acid and that on oxidation with $KMnO_4$ it gives 4-oxy quinazoline. On oxidation with hydrogen peroxide, however, two products are formed one $C_{11}H_{10}N_2O$ m.p. 168° and the other $C_{11}H_{10}N_2O_2$ m.p. 213°. Vasicine is a mono acid base, insoluble in cold alkali but soluble in hot, forming alkali salts. On acidification of its alkaline solution with carbonic acid and extraction with chloroform, a substance differing markedly from vasicine is obtained. It has already been shown that vasicine is not a propyl or an isopropyl

quinazoline and, therefore, the only other alternative formulæ are the following :—



A



B

B is improbable since its chloro derivative can be easily obtained with $POCl_3$ and PCl_5. A, on the other hand, gets further support from the oxidation product formed with hydrogen peroxide. Investigation of these may throw further light on the constitution of vasicine.

Other drugs studied during the period under review are :—

(*a*) *Ferula narthex.*

(*b*) *Gentiana kurroo.*

(*c*) *Senecio chrysanthemoides.*

(*b*) *Oils and Fats.*

Vateria indica.—Reference was made last year to the fat from the kernels of *V. indica.* This work has now been completed and the summary of the results is given below :—

V. indica, Linn (N. O. Dipterocarpeæ. Vern. *safed damar*), is a large handsome tree forming evergreen forests at the foot of the western Ghats from Kanara to Travancore. The fruit or the seed is ovoid 2″-2½″ long with a hard white kernel which on pressing or boiling is reported to yield 50 per cent. of a pale yellow fat known as "piney tallow". The chemical composition of "piney tallow" has been reported by G. Dal Sie (Gazz. Chim. Ital. 1896, p. 107) to consist of glycerides of palmitic (75 per cent.) and oleic acid (25 per cent.). The results of our experiments, on the other hand, show that the fat consists mainly of the glycerides of stearic and oleic acids and these results are in conformity with those obtained by Miss Jones (Chemistry and Industry 1931, Vol. 50, p. 498 T).*

The seeds yield 20-22 per cent. of a pale yellow oil when extracted at an elevated temperature (60° C) under a hydraulic press, but the colour rapidly gets bleached on exposure to the sun and air. This oxidation is quite marked, so much so that in some of the samples that had been allowed to stand in air for some weeks, the iodine value fell from 40 to under 20. The physical characteristics of the fat have already been

* This paper appeared when our work had been completed. Consequently its publication has been withheld.

reported upon (Forest Research in India, 1930-31) but the chemical constants of the mixed fatty acids are as follows :—

	per cent.
Mean molecular weight	286
Iodine value	38·6
Saturated acids	53
Unsaturated acids	47

The individual separation of the acids was conducted, in the usual manner, by fractionation of their methyl esters and the data for the free acids, isolated from the esters, indicate the presence of palmitic (6 per cent.), stearic (45 per cent.), arachidic (2 per cent.) and oleic (47 per cent.) acids. But attempts to isolate and identify palmitic and arachidic acids have not been successful. The unsaponifiable matter has given a sitosterol m.p. 133-134° C.

This work on *V. indica* lead us to suggest that the fat may form an admirable true vegetable tallow. Among the ingredients of the size paste, used in yarn weaving, animal tallow is the most important of the softening substances by virtue of its emollient properties. With the expansion of the cotton weaving industry in India, the demand for tallow is bound to increase since this is the only right type of sizing material that can be suitably employed and no reliable substitute has yet been discovered. A true vegetable substitute with all the essential properties will certainly attract the attention of the cloth mills and may develop into a rival industry to animal tallow. Comparison of the physical and chemical properties of piney tallow with animal tallow shows how closely related these are :—

——	Beef tallow (Australian).	Mutton tallow (Australian).	Piney tallow (Indian).
Melting point	43·44° C.	45° C.	40° C.
Iodine value	35·8	42·5	40
Solid acids (palmatic and stearic)	55·5 per cent.	54·2 per cent.	53 per cent.
Liquid acids (Oleic and Linoleic)	44·5 per cent.	45·8 per cent.	47 per cent.

In other respects as well, *V. indica* fat stands good comparison with either synthetic vegetable tallows or animal tallow and, therefore, in the opinion of certain experts is admirably suited for yarn sizing.

The seeds of *V. indica* are not exported in any large quantity and only small amounts are collected for local consumption. The figures that have been obtained through the courtesy of the Forest Utilization

Officer, Madras, show that in 1929-30 about 350 tons were exported and about 30 tons were collected for local consumption. If piney tallow is to find an application in the manner suggested above it is evident that much larger quantities of it will have to be collected. It has not been possible to get figures showing the total quantity of seeds that may be available in any one year but it is presumed that this figure cannot be large enough to supply the total quantity of vegetable tallow that would be needed to replace animal tallow. Need for exploring other sources of fats of the type of piney tallow is, therefore, obvious. Two other such fats that could be utilised for sizing purposes are the *kokum* butter (*Garcinia indica*) and the Chinese vegetable tallow (*Sapium sebiferum*) both of which are the minor forest products of India and possess very nearly the same properties as the piney tallow. The cost of extraction of these fats cannot be very high and, therefore, it appears possible to place on the market vegetable tallows at competitive prices.

Actinodaphne hookeri.—While the seeds were being examined for their alkaloidal content it was noticed that these contained considerable amounts of a crystalline fat. It was, therefore, extracted by pressing under a hydraulic press, keeping the temperature at 60°C, and a study of its chemical and physical constants was made. Preliminary results, so far obtained, show it to be almost pure trilaurin (about 94 per cent.). The presence of a single triglyceride in a seed is not common and, therefore, the study of this oil is interesting from an academic point of view. At the same time it is of economic interest in that it may become an indigenous source of lauric acid. The seeds give 65 per cent. of the kernels which yield 75 per cent. of the fat by solvent extraction. The following are the general characteristics of the fat :—

Melting point	44°-45°C.
Refractive Index at 30° C.	1·4490
Saponification value	255·5
Iodine value	10·94
Acid value	3·99

Mixed fatty acids have the following chemical constants :—

Mean molecular weight	202
Iodine value	3·15
Saturated Acids	91%
Unsaturated Acids	6%
Melting point	41° C.

Apart from the fat described above, the husk on the kernels, on extraction with petroleum ether, gave 25 per cent. of a liquid oil which on standing and cooling deposited appreciable amounts of a crystalline

fat, which presumably is trilaurin. The liquid oil on filtration and removal of solid trilaurin gave the following constants :—

Colour	reddish brown.
Specific Gravity at 20°	0·9163
Refractive Index at 25°	1·4550
Saponification value	199·5
Iodine value	55

It appears that the kernels contain the fat and the husk the liquid oil. The presence of olein in the kernel fat and trilaurin in the husk oil is most probably due to the unavoidable contamination of the kernels by the husks and *vice versâ*. Further work on the composition of the fat and the oil and the nature of their various components is in progress.

(c) *Essential oil.*

Inula spp.—In India some 20 species of *Inula* occur and many of them are extremely abundant plants, for example, *I. cappa* DC., a shrub met with on temperate Himalayas from Kumaon to Bhutan at 4,000—6,000 ft. *Inula racemosa* and *I. roylei* are found in Kashmir and have, hitherto, been used mainly for adulteration of *kut* (*Saussurea lappa*). Of these *I. racemosa* is better known because of its stronger aromatic odour. The dried roots have a weak odour, resembling orris and camphor. *I. racemosa* and *I. roylei* are not included in the British Pharmacopœia. Extra Pharmacopœia, however, mentions inula or elecampane, the rhizomes and roots of *I. helenium* (Fam. Compositæ), a large perennial herb indigenous to Central Europe and Asia. The rhizomes and branching roots when extracted give 35-45 per cent. of inulin and 1-2 per cent. of alantol, a crystalline or somewhat oily substance consisting chiefly of alantolactone which is commercially known as " helenin " or " alantcamphor " or " oil of elecampane".

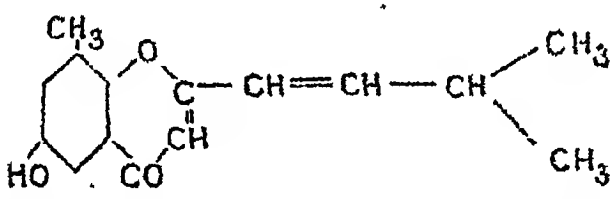
Examination of *I. racemosa* and *I. roylei* have given the following results :—

Species.	Alantolactone.	Alantol.	Inulin.
	per cent.	per cent.	per cent.
I. racemosa	7·0	1·0	10·0
I. roylei	1·5	1·5	10·10
I. helenium	1·5	0·5	35—45

These results indicate that *I. racemosa* is superior to *I. helenium* of commerce in its essential oil content.

(*d*) *Colouring matter.*

Garcinia morella.—This is in continuation of the work first investigated by the late Mr. M. G. Rau of the Chemical Branch, reference to which was made in the annual report for the year 1924-25. Morellin is an orange, crystalline, colouring matter obtained from the husk of *Garcinia morella* seeds. Analyses and many of its derivatives tend to indicate for morellin the formula C_{13} H_{16} O_3. It appears to contain a hydroxyl group and a ketonic group but no methoxyl and the third oxygen atom in the molecule appears to be of etheric constitution, probably a γ pyrone. On fusion with alkali it gives iso-valerianic acid and a phenolic substance (m.p. 215° and formula C_8 H_8 O_4) which appears to correspond to 1 methyl 2 : 5 dioxy—3 benzoic acid. Zinc dust distillation, on the other hand, gives no naphthaquinone but only a small quantity of an oil together with a volatile hydrocarbon. Reduction with red phosphorus and hydroiodic acid gave no naphthalene derivative. Morellin appears to contain a system of two conjugated double linkages since two molecules of bromine are absorbed by it. The experimental evidence collected, hitherto, appear to suggest for morellin the constitution—



The results given above indicate that morellin is distinctly different from mangostin (the colouring matter of *Garcinia mangostina*) which has been shown to be a lapachol derivative. The constitutional formula suggested for morellin is tentative and further work is necessary to substantiate the above views.

Forest Soils.

Dehra Dun Soils.—Work is in progress on the study of the changes in the properties of soil as it passed from cultivated agricultural land to forest land. The agricultural land of 1927 is now covered with a young forest and has been divided into four areas, namely, the *chir* (*Pinus longifolia*), the *shisham* (*Dalbergia sissoo*), the teak (*Tectona grandis*) and the *sal* (*Shorea robusta*) area.

The first set of results were obtained in 1927. The second set of experiments are being conducted now and from the results hitherto collected it is not possible, at the present stage, to draw any reasonable conclusions.

Apart from the above, a large number of analyses have been made for the Silviculturist, Forest Research Institute, as well as for officers from other provinces in India.

Miscellaneous Enquiries.

Calorific values.—Reference was made last year to the progress of this work which has now been completed. During the last two years the calorific values of over 150 Indian woods (separately both for heartwood and sapwood) have been determined and the main conclusions drawn are (*a*) that the average calorific value of Indian woods is 5,016 Cals. when represented on "zero-moisture" and ashless basis and (*b*) that for academic purposes it is advisable to determine heat values of heartwood and sapwood separately, because in many cases these have been found to differ to an appreciable extent, the highest variation being 550 Cals. in the case of *Sterculia urens.*

Composition for reconditioning abrased spike holes.—Further tests with "Fridera" the composition for reconditioning spike holes, have been carried out by the North-Western Railway at Lahore on lines which carried an average volume of traffic (about 20 trains daily). 569 spike holes were treated between July 10th and 28th, 1931 and on the first inspection on 31st July, 30 spikes (that is 5·2 per cent.) were found loose, but on the second inspection made on 27th January 1932 no further loosening was observed nor was any variation in the gauge noticed during the same period. The total cost per hundred spike holes treated worked out at Rs. 6·28 or one anna per spike hole.

The process of manufacturing "Fridera" is given in the Indian Patent 18333 and a detailed account of the composition in the Technical Paper No. 282, published by the Railway Board, Delhi.

A large number of analyses of various substances were undertaken on behalf of the Officers of the Institute and Forest Officers. Particular mention may be made of the following:—

Bamboos, Casein Cements, Glues, Paints, Rosha grass oil, Tannins, Katha, etc.

CHAPTER VII.

PUBLICATIONS OF 1931-32.

Serial No.	Title of Publications.	Author.	Date of issue.
	FOREST RECORDS.		
	Issued.		
1	Immature Stages of Indian Coleoptera (8)—(Cerambycidae—contd.).	J. C. M. Gardner .	June 1931.
2	Standard, Commercial and Heartwood Volume Tables (Factory Working) for Khair (*Acacia catechu*) in North India.	H. G. Champion and Ishwar Dass Mahendru.	October 1931.
3	Immature Stages of Indian Coleoptera (9)	J. C. M. Gardener .	Do.
4	Investigation on the Seed and Seedlings of *Shorea robusta*.	H. G. Champion and B. D. Pant.	Do.
5	The Use of Stumps (Root and Shoot Cuttings) in Artificial Regeneration.	Do. . .	February 1932.
6	Notes on *Pinus longifolia*.—The Plantations in Dehra Dun and Central Provinces and Miscellaneous Seed Studies.	Do. . .	January 1932.
7	New Indian Curculionidae . . .	Sir Guy Marshall .	Do.
8	The Life-History and Control of *Celosterna scabrator*,	C. F. C. Beeson .	Do.
9	New Species of Exocentrus Mulsant from India.	W. S. Fisher . .	February 1932.
10	Volume Tables and Diameter Growth Curve for Semal (*Bombax malabaricum*).	Ishwar Das Mahendru.	March 1932.
	In Press.		
11	Immature Stages of Indian Coleoptera (10) (Anthribidae).	J. C. M. Gardner .	(April 1932.)
12	Treatment of Babul (*Acacia arabica*) in Berar.	S. A. Vahid . .	(May 1932.)
13	Entomological Investigations on the Spike Disease of Sandal (*Santalum album*)—Part I.—An Introductory Survey of the Problem.	C. Dover . .	

Serial No.	Title of Publication.	Author.	Date of Issue.
14	Immature Stages of Indian Coleoptera (11) Platypodidae.	J. C. M. Gardner.	
15	The Sutlej Deodar—Its Ecology and Timber Production.	R. M. Gorrie.	
	FOREST BULLETINS.		
	Issued.		
16	A List of Trade Names of Indian Timbers (Reprint).	....	December 1931.
17	The Herbarium of the Forest Research Institute.	R. N. Parker . .	October 1931.
18	Summary of results of Treated Experimental Sleepers laid in the various Railway Systems of India.	F. J. Popham . .	November 1931.
19	Preservation of Indian Timbers.—The Open Tank Process.	F. J. Popham .	November 1931.
20	List of Plants collected in West Nepal .	....	January 1932.
	In Press.		
21	Identification of Important Indian Sleeper Woods.	K. A. Chowdhury.	
22	The Problem of the Pure Teak Plantation.	H. G. Champion.	
23	The Calorific Values of some Indian Woods.	S. Krishna and S. Ramaswami.	
	OTHER PUBLICATIONS.		
	Issued.		
24	Progress Report of Forest Research Work in India for the year 1929-30.	....	May 1931.
	In Press.		
25	Progress Report of the Imperial Forest College, Dehra Dun, for the year 1930-31.	....	(April 1932.)
26	Progress Report of Forest Research Work in India, for the year 1930-31.	....	(June 1932.)

CONTRIBUTED TO PERIODICALS.

Pintar.—An attempt to utilise *Pinus longifolia* tar as a road surfacing material. By B. S. Varma, F. D. Ardagh and S. Krishna, 'Indian Forester' Vol. LVII, July 1931, page 313.

Some methods of Testing the Comparative Durability of Indian Timbers in relation to Termite attack, by C. Dover, 'Indian Forestor' Vol. LVII, July 1931, pages 341-351.

Sandal wood and its Indian substitute, by K. A. Chowdhury, 'Indian Forester' Vol. LVII, September 1931, pages 431-433.

Loss of increment in Teak Defoliation, by C. F. C. Beeson, 'Indian Forester' Vol. LVII, November 1931, pages 542-545.

Indian *Ephedras*, their Chemistry and Pharmacology, by Lt. Col. R. N. Chopra (Calcutta); S. Krishna (Dehra Dun) and T. P. Ghose (Dehra Dun), Journal of the Indian Medical Research, Vol. XIX, No. 1, 1931, page 177.

The early stages of two species of Rhipiceridae (Sandalidae) from India, by J. C. M. Gardner, Transactions Entomological Society, London, Vol. LXXIX, No. iii, 1931, pages 427-430.

The Oil from the Seeds of *Putranjiva roxburghii* Wall. By S. Krishna and S. V. Puntambekar. Journal of the Indian Chemical Society, Vol. VIII, page 301.

Fridera.—A composition for reconditioning abrased spike holes in railway sleepers. By S. Krishna and T. P. Ghose (Technical Paper No. 282, Railway Board, Delhi).

Indian Patent 18333 of 1931.

The Seeds of *Vateria indica*, Linn. as a source of Vegetable Tallow. By S. V. Puntambekar and S. Krishna, 'Indian Forester' Vol. LVIII, January 1932, page 69.

The Duration of Life of some Indian Mammals, by C. Dover, 'Indian Forester' Vol. LVIII, February 1932, pages 81-90.

Note on "The Leaf curl of cotton in Garden Zinnias in North India", by R. N. Mathur, to be published in the Indian Journal of Agricultural Science.

APPENDIX I.

Statement showing Officers in charge of Branches and Sections during the year 1931-32.

Branch.	Officer in Charge.	Section.	Officer in Charge.	From	To
Silviculture .	Mr. M. V. Lauric, Offg. Silviculturist	....	....	1-4-1931	8-11-1931
	Mr. H. G Champion, Silviculturist.	....	....	9-11-1931	31-3-1932
Botany . .	Mr R. N Parker, Forest Botanist.	....	....	1-4-1931	31-3-1932
		Mycology .	Dr. K. D. Bagchee	1-4-1931	31-3-1932
		Oecology .	Mr. C. E. Parkinson, Burma Forest Service.	1-4-1931	5-6-1931
Economy .	Capt H. Trotter, Forest Economist.	....	....	1-4-1931	31-3-1932
		Minor Forest Products.	Mr. F. D. Ardagh	1-4-1931	31-3-1932
		Timber Testing	Mr. L. N. Seaman	1-4-1931	31-3-1932
		Wood Preservation.	Mr. F. J. Popham	1-4-1931	22-3-1932
			Mr. S. Kamesam	23-3-1932	31-3-1932
		Seasoning .	Dr. S. N. Kapur .	1-4-1931	23-8-1931
			(Capt. H. Trotter)	24-8-1931	31-1-1932
			Dr. S. N. Kapur .	1-2-1932	31-3-1932
		Wood Technology.	Mr. K. A. Chowdhury.	1-4-1931	17-5-1931
			(Capt. H. Trotter)	18-5-1931	25-5-1931
			Mr. K. A. Chowdhury.	26-5-1931	31-3-1932
Entomology .	Dr. C. F. C. Beeson Forest Entomologist.	....	....	1-4-1931	26-11-1931
	(Mr. R. N. Parker) .	....	....	27-11-1931	14-2-1932
	Mr. J. C. M. Gardner. Offg. Forest Entomologist.	....	....	15-2-1932	31-3-1932
		Systematic Entomology.	Mr. J. C. M. Gardner.	1-4-1931	10-6-1931
			(Mr. H. S. Deans)	11-6-1931	15-6-1931
			Dr. C. F. C. Beeson	16-6-1931	30-6-1931
			Mr. C. Dover, In charge current duties.	1-7-1931	14-2-1932
			Mr. J.C.M. Gardner	15-2-1932	31-3-1932
Biochemist .	Dr. S. Krishna .	....	....	1-4-1931	31-3-1932

APPENDIX II.

ANNUAL FORM No. 24.

FOREST RESEARCH INSTITUTE.

Summary of Revenue and Expenditure of the different Branches during 1931-32.

Budget Heads.	Direction and Chemistry Branch.	Silviculture Branch.	Botany Branch.	Entomology Branch.	Economic Branch.	TOTAL.
1	2	3	4	5	6	7
REVENUE.	Rs	Rs.	Rs.	Rs.	Rs.	Rs.
V.—Miscellaneous—						
(*b*) Other sources . .	5,007	371	216	58	2,500	8,161
(*d*) Sale of timber and furniture from Seasoning and Wood Workshop Depot	..	..	..	.	1,303	1,303
VI.—*Deduct* Refunds—						
Non-voted . . .	..	..	..	..	..	..
Total Revenue .	5,007	371	216	58	3,812	9,464
EXPENDITURE.						
A.—Conservancy, Maintenance and Regeneration—						
C.—Live stock, stores, tools and plant—						
C. 1.—Purchase of stores, tools and plant.	247	1,010	194	581	3,117	5,740
C. 2.—Communications and Buildings, New Work—						
(*a*) Roads and bridges .	..	..	..	..	..	..
(*b*) Buildings . . .	..	..	..	..	..	..
(*c*) Other Works . .	..	..	..	..	..	..
C. 3.—Communications and Buildings, Repairs and Maintenance—						
(*a*) Roads and Bridges .	..	..	..	..	..	..
(*b*) Buildings . . .	..	..	..	..	..	..
(*c*) Other charges . .	1,281	..	..	..	..	1,281
C. 4.—Miscellaneous—						
(1) Temporary Establishment on daily labour.	8,105	2,315	1,167	3,893	56,289	74,769
(2) Purchase of Timber for seasoning and preserving (including freight and carting charges).	..	..	..	..	12,237	12,237
(3) Purchase of coal, raw materials, chemicals and apparatus.	1,831	12	.	357	18,104	20,307
(4) Other charges . .	1,723	3,622	1,464	1,212	26,223	34,274
Total A.—Conservancy, Maintenance and Regeneration	13,190	7,559	5,825	6,073	1,16,060	1,48,707

APPENDIX III.

List of Publications by the Forest Research Institute, Dehra Dun.

I.—BULLETINS (OLD SERIES).

	Price (exclusive of packing, postage, etc.). Rs. A. P.
1. Note on the Bee-Hole Borer of Teak in Burma, by E. P. Stebbing. (*Out of print*)	..
2. Note on the Quetta Borer (*Coleotechnites sarius*), by the same author	0 8 0
3. Note on the Chilgoza (*Pinus Gerardiana*) Bark Boring Beetles of Zhob, Baluchistan, by the same author	0 8 0
4. *Ficus elastica*: its natural growth and artificial propagation, with a description of the method of tapping the tree and of the preparation of its rubber for the market, by F. M. Coventry	0 12 0
5. Notes on a Visit to some European Schools of Forestry, by E. P. Stebbing. (*Out of print*)	..
6. Memorandum on Mechanical Tests of some Indian Timbers, by W. H. Everett	0 2 0
7. Note on the Chilgoza Forests of Zhob and the Takht-i-Sulaiman, by E. P. Stebbing. (*Out of print*)	..
8. Note on the Life History of *Hoplocrambyx spinicornis* (The Singhbhum Sal Borer), by the same author	0 9 0
9. Note on the Influence of Forests on the Storage and Regulation of the Water-Supply, by S. Eardley-Wilmot (*Out of print*)	..
10. Note on the Dalbergia Borer of Baluchistan. (*Batocera rufa*), by E. P. Stebbing	0 7 0
11. On Some Assam Sal (*Shorea robusta*) Insect Pests, by the same author	1 10 0

II.—LEAFLETS- (*All Out of print.*)

1. The Sal Bark-Borer (*Sphaerotypes sivalikensis*, Steb.), by E. P. Stebbing	..
2. The Teak Defoliator (*Hyblaea puera*, Cram.), by the same author	..
3. The Teak Leaf Skeletoniser (*Pyrausta machaeralis*, Wlk.), by the same author	..
4. The Larger Deodar Bark-Borer (*Scolytus major*, Steb.), by the same author	..
5. The Blue Pine "Polygraphus" Bark-Borer (*Polygraphus major*, Steb.), by the same author	..

III.—PAMPHLETS.

1. Note on Utilisation of Khair Forests in Eastern Bengal and Assam, by Puran Singh. (*Out of print*)	..
2. The Attack on the Bark-Boring Beetle in the Coniferous Forests in the Sunkh Catchment Area, by E. P. Stebbing. (*Out of print*)	..
3. A Glossary of Forest Technical Terms for Use in Indian Forestry, by A. M. F. Caccia. (*Out of print*)	..
4. Note on Lac and Lac Cultivation, by D. N. Avasia. (*Out of print*)	..
5. Notes on Sal in Bengal, by A. L. Melville. (*Out of print*)	..
6. Note on Forest Reservation in Burma in the Interests of an Endangered Water-Supply, by A. Rodger	1 0 0
7. Note on Andaman Marble-Wood or Zebra Wood (*Diospyros Kurzii*, Hiern.), by R. S. Troup.- (*Out of print*)	

III.—PAMPHLETS—*contd.*

	Price (exclusive of packing, postage, etc.). Rs. A. P.
8. Note on the Collection of Statistical Data relating to the principal Indian Species, by A. M. F. Caccia	0 10 0
9. Tables showing the Progress in Working-Plans in the Provinces outside the Madras and Bombay Presidencies up to 31st December, 1908, by the same author	0 10 0
10. Note on Burmese Leza Wood (*Lagerstræmia tomentosa*, Presl.), by R. S. Troup	0 2 0
11. Note on Carallia Wood (*Carallia integerrima*, DC.), by the same author. (*Out of print*)	..
12. Note on Petwun or Trincomali Wood (*Berrya Ammonilla*, Roxb.), by the same author. (*Out of print*)	..
13. Note on Burmese In Wood (*Dipterocarpus tuberculatus*, Roxb.), by the same author. (*Out of print*)	..
14. Note on Burma Padouk (*Pterocarpus macrocarpus*, Kurz.), by the same author. (*Out of print*)	..
15. Note on the Preservation of Bamboos from the Attacks of the Bamboo Beetle or "Shot-Borer", by E. P. Stebbing	0 7 0
16. Note on the Best Season for Coppice Fellings of Teak (*Tectona grandis*), by R. S. Hole	0 4 0

IV.—BULLETINS (NEW SERIES).

1. Note on Calorimetric Tests of some Indian Woods, by Puran Singh	0 2 0
2. Memorandum on Teak Plantations in Burma, by F. A. Leete	0 10 0
3. Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by R. S. Pearson	0 4 0
4. Second Edition of the Glossary of Technical Terms for Use in Indian Forestry, by A. M. F. Caccia, revised by R. S. Troup (*Revised and issued as Forest Record, Vol. XV. Part II*)	0 6 0
5. The Blue Pine Tomicus Bark-Borer (*Tomicus Ribbentroppi*), by E. P. Stebbing	0 2 0
6. Memorandum on the Oil-Value of Sandalwood, by Puran Singh	0 2 0
7. Note on the Chemistry and Trade Forms of Lac, by the same author	0 3 0
8. Note on some Germination Tests with Sal Seed (*Shorea robusta*), by R. S. Troup	0 2 0
9. Note on Resin-Value of *Podophyllum Emodi* and the best season for collecting it, by Puran Singh	0 1 3
10. Note on the Bark-Boring Beetle Attack in the Coniferous Forests of the Simla Catchment Area, 1907-1911, by R. S. Hole	0 3 0
11. A Further Note on some Casuarina Insect Pests of Madras, by V. Subramania Iyer	0 14 0
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13. Note on *Ligno Protector* as a possible means of preventing timber from splitting while seasoning by R. S. Pearson	0 5 0
14. A Further Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by the same author	0 3 0
15. Note on the Technical Properties of Timber, with special reference to *Cedrela Toona* wood while seasoning, by the same author	0 3 0
*16. Note on Gumhar (*Gmelina arborea*, Roxb.), by A. Rodger	0 3 0
17. Note on Biju Sal or Vengai (*Pterocarpus Marsupium*, Roxb.), by the same author	0 4 0
18. Note on Sain or Saj (*Terminalia tomentosa*, W. and A.), by the same author	0 5 0

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20. Note on Sandan (*Ougeinia dalbergioides*, Benth.), by the same author	0 3 0
21. Note on Dhaura Bakli (*Anogeissus latifolia*, Wall.), by the same author	0 4 0
22. Note on the Causes and Effects of the Drought of 1907 and 1908 on the Sal Forests of the United Provinces, by R. S. Troup.	0 5 0
23. Note on the Preparation of Indian Forest Floras and Descriptive Lists, by R. S. Hole	0 4 0
24. Note on Turpentines of *Pinus Khasya*, *Pinus Merkusii* and *Pinus excelsa*, by Puran Singh	0 2 0
25. Development of the Culms of Grasses, by R. S. Hole	0 2 0
26. Note on the Resin Industry in Kumaon, by E. A. Smythies	1 4 0
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28. Note on Dhauri (*Lagerstramia parviflora*), Roxb.), by the same author	0 4 0
29. Note on Sundri Timber (*Heritiera minor*, Lam.), by R. S. Pearson	0 3 0
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37. Note on the Contraction and Warping which takes place in *Pinus longifolia* timber while seasoning, by the same author	0 11 0
38. The Construction of Calcareous Opercula by Longicorn Larvæ of the Group *Cerambycini* (Coleoptera, Cerambycidæ), by C. F. C. Beeson	0 3 0
39. Note on Hollong Timber (*Dipterocarpus pilosus*, Roxb.), by R. S. Pearson	0 4 0
40. Note on Pyinma, Ajhar or Jarul Wood (*Lagerstramia Flos-Reginæ*, Retz.), by the same author	0 6 0
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42. Note on Haldu (*Adina cordifolia*, Hook. f.), by C. E. C. Cox	0 8 0
43. Note on *Odina Wodier*, Roxb., by the same author	0 8 0
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47. Volume Tables and Form Factors for Sal (*Shorea robusta*), by the same author	0 6 0
48. Note on Kindal (*Terminalia paniculata*), by R. S. Pearson	0 6 0
49. Note on Thingan (*Hopea odorata*, Roxb.), by A. Rodger	0 7 0
50. Note on Gurjun or Kanyin, compiled by W. A. Robertson	0 4 0
51. An Investigation of certain factors concerning the Resin tapping Industry in *Pinus longifolia*, by H. G. Champion	0 8 0
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*Vol. XII,	Part I.	—Volume and Outturn Tables for Sal, by S. H. Howard	1 2 0

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